New Scientist

WEEKLY 26 October 2024

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OUT OF THE VOID

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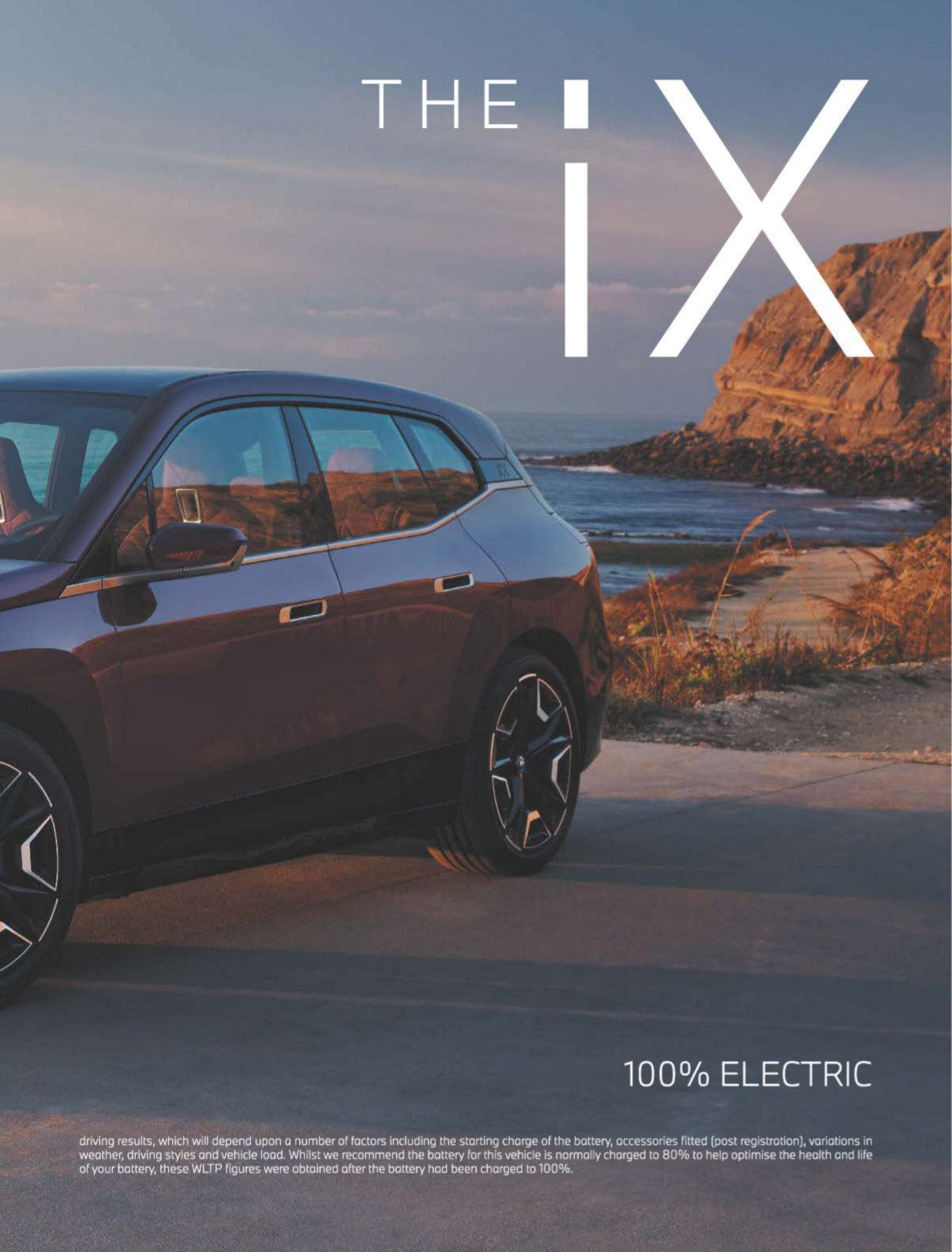

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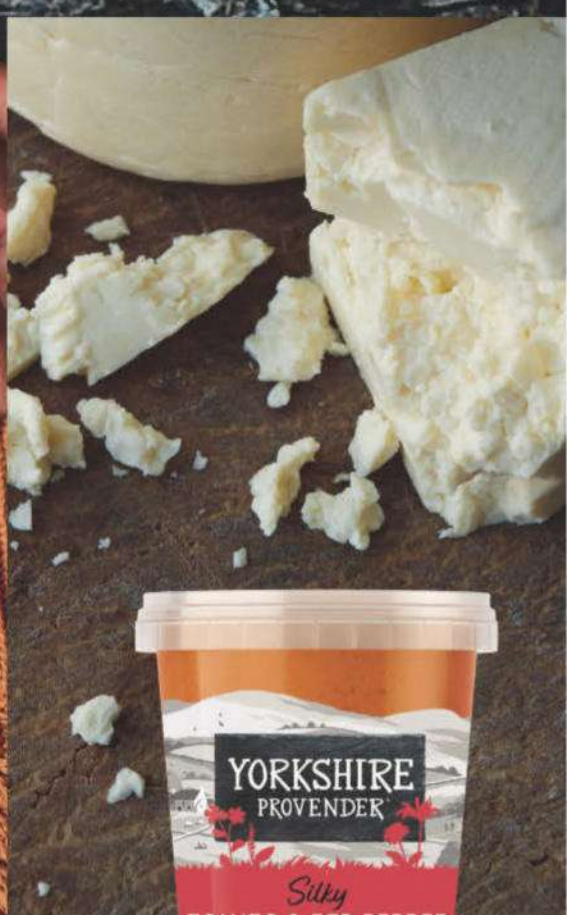

AS GOOD AS HOMEMADE

if you had the time...

This week's issue

On the cover

38 Out of the void
We finally know if something can escape a black hole, but the answer plunges us into a deeper mystery

New Scientist
OUT OF THE VOID
We finally know if something can escape a black hole, but the answer plunges us into a deeper mystery

Vol 264 No 3514
Cover image: Michael Strevens

14 US election special: From climate to healthcare

10 What bullying does to the brain

42 Why your creativity peaks at the moment you fall asleep

21 How puppies ask for help
25 Brown dwarf has surprise twin
51 The perils of potted plants
25 Why computers need a new way to count

42 Features
"The creativity sweet spot occurs when you start to lose control of your thoughts"

News

13 De-extinction dream
Company claims it has a nearly complete Tasmanian tiger genome

19 Fang you very much
Invasive snake is surviving in Britain by living in attics

20 Nature's rules
Is there a pattern hidden in the laws of physics?

Views

27 Comment
Will Eaves on finding the spark of creativity

28 The columnist
Graham Lawton roots for urban tree planting

30 Aperture
Space telescope offers a cornucopia of celestial treats

32 Letters
We must teach everyone how to face the climate crisis

34 Culture
Transcendent exhibit tasks AI with writing choral music

SHUTTERSTOCK/TETSUO ARADA

23 Every breath you take Microplastics found in dolphin exhalations

Features

38 Black holes, inside and out
The confounding questions raised by solutions to the infamous black hole paradox

42 Twilight zone
The weird moments before slumber could lead to fresh treatments for sleep conditions

46 Food and fossil fuels
How to feed 10 billion people without trashing the planet

The back pages

51 Debunking gardening myths
The perils of potted plants

52 Puzzles
Try our crossword, quick quiz and logic puzzle

54 *Almost* the last word
Is there any evidence disproving that we're in a simulation?

56 Feedback
Matters of time and malevolent book displays

56 Twisteddoodles for *New Scientist*
Picturing the lighter side of life

Elsewhere on New Scientist

Instant Expert

Mysteries of the mind

What is really going on inside this lump of interconnected tissue within your skull? Join six pioneering researchers who will illuminate the neural underpinnings of thought, emotion and communication. Gain their insights on topics such as the effects of screen time and explore strategies to optimise brain performance. On 7 December at London's Congress Centre.

newscientist.com/events

Online Event

Journey to the poles

The Arctic and Antarctica are harsh yet beautiful regions that have fascinated scientists for centuries. In this free online event on 6 November, glaciologist Ulyana Horodyskyj and *New Scientist* features editor Leah Crane present big stories on polar science – including IceCube, the Antarctic neutrino detector that has identified cosmic signals from across the Milky Way.

newscientist.com/events

Podcast

Weekly

How does being bullied change your brain? The team also delve into the 2024 state of the climate report – which assesses 35 planetary vital signs – and discuss the latest in an attempt to resurrect the extinct Tasmanian tiger, or thylacine. Plus, find out about SpaceX's fifth test of its Starship rocket, in which the firm attempted to catch the booster on its return to the launchpad.

newscientist.com/nspod

SHUTTERSTOCK/DAISY DAISY

Where is my mind? Hear the latest research on our inner world

FELIPE PEDREROS, ICECUBE/NSF

Polar stories Antarctica is the ideal spot for cosmic particle physics

Video

Asteroid spotter

NASA's NEO Surveyor space telescope is under construction at the Jet Propulsion Laboratory (JPL) in Pasadena, California. It will identify potentially hazardous asteroids and comets that come close to Earth's orbit, giving us advance warning. "The more time we have, the more options we have to actually do something about it," says Amy Mainzer at JPL.

youtube.com/newscientist

Newsletter

Fix the Planet

Environment reporter Madeleine Cuff looks at technologies that can help fire services spot a smouldering fire. Satellites and surface cameras can already spot areas that are ablaze, but a new breed of early warning systems relies on chemical sensors to detect the first whiff of smoke in the air.

newscientist.com/fix-the-planet

Newsletter

"Lightning strikes can smoulder for days before suddenly erupting into flames"

Essential guide

From tremendous chains of galaxies to supermassive black holes, our universe is a place of grandeur and spectacle. Find out how we are probing the cosmos like never before in this 24th *Essential Guide*. Available to download in the *New Scientist* app or to purchase in print from our shop.

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The fossil fuel diet

Food that is healthy for you can still be catastrophic for the planet

WOULD you like the crude oil dressing with your tomato salad, or how about the coal-crusted sea bass? If only it were so easy to see the effect of fossil fuels on food production, even environmentally friendly foodies might find their lunch turning to ash in their mouth.

The global food system is more dependent on fossil fuels than we tend to recognise. They power the tractors that plough fields and the pumps that suck up groundwater to irrigate. They are used to make fertiliser and other agrochemicals. They propel the trucks, trains and ships that transport food. In fact, we may as well think of ourselves as eating fossil fuels.

So says energy scholar Vaclav Smil (see page 46) who has done some calculations to illustrate this point. He estimates producing an average baguette requires the equivalent of about 30 millilitres of diesel fuel. A kilogram of roast chicken requires over 300 millilitres. Surprisingly, a kilogram of tomatoes cultivated in a heated greenhouse and trucked far away requires twice as much diesel as the bird.

"For a healthier planet, we must find a way to stop 'eating' fossil fuels"

Seafood, especially farmed fish (see page 16), is often even worse due to the inefficiency of being fed on smaller, wild-caught fish. Producing a kilogram of farmed sea bass uses a shocking 2 litres of diesel, according to Smil.

This intensive use of energy from fossil fuels helps us produce a global food surplus. It is also a major reason why agriculture generates around a third of greenhouse gas emissions and is a dominant driver of biodiversity loss. For a healthier planet, we must find a way to stop "eating" fossil fuels.

Unfortunately, ending that dependency will be even tougher than decarbonising the power grid or transportation.

But there are a thousand things we could be doing better now. Slashing food waste should be a top priority. Government should support farming practices that conserve carbon-storing soil and use water and fertiliser better. And we should eat much less meat. If we don't, we are stuck seasoning each bite with diesel. ▮

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If we are serious about net zero, why are we opening new oil & gas fields?

Here's why.

You may ask whether a company that continues to produce more oil and gas is really committed to the energy transition. And it's a fair question, when you consider that 99.6% of our global energy production is in fossil fuels.

Today, oil and gas operations account for around 15% of total energy-related emissions globally. And yet we continue the search for oil and gas. Indefensible, some would say. The way we see it, it's the responsible thing to do.

Why? Well, last year saw record levels of renewable energy production, but we also experienced record demand for oil and gas. Even the most optimistic forecasts say that the world will still need oil and gas for decades to come. So it's important we keep investing in both renewables and oil and gas, to help create a more balanced and secure energy system.

But is it possible to speed up the transition? Well, that's what we're working on and it's one of the reasons our gross spend was a record 2.9 billion US dollars on renewables and lower carbon solutions last year. That's 20% of our global gross investments, compared to 14% the year before.

Our ambition is that our investments in profitable renewables and lower carbon solutions will reach 50% of our annual gross expenditure in 2030.

But if oil is going to be part of the bigger picture for decades to come, how we run our business matters. That's why we're always searching for better ways to produce it. Already, we have some of the lowest oil and gas production emissions in the world, but we still emit 11.6m tonnes of CO_2 a year. By 2030, we aim to make a net 50% reduction in these emissions (compared to 2015 levels) to 7.7m tonnes.

And we'll keep searching for better ways to do everything, across all of our business, from innovations to new technology. Every small solution helps towards solving the bigger picture. That's why we will always keep searching for better.

An energy company searching for better.

equinor.co.uk

News

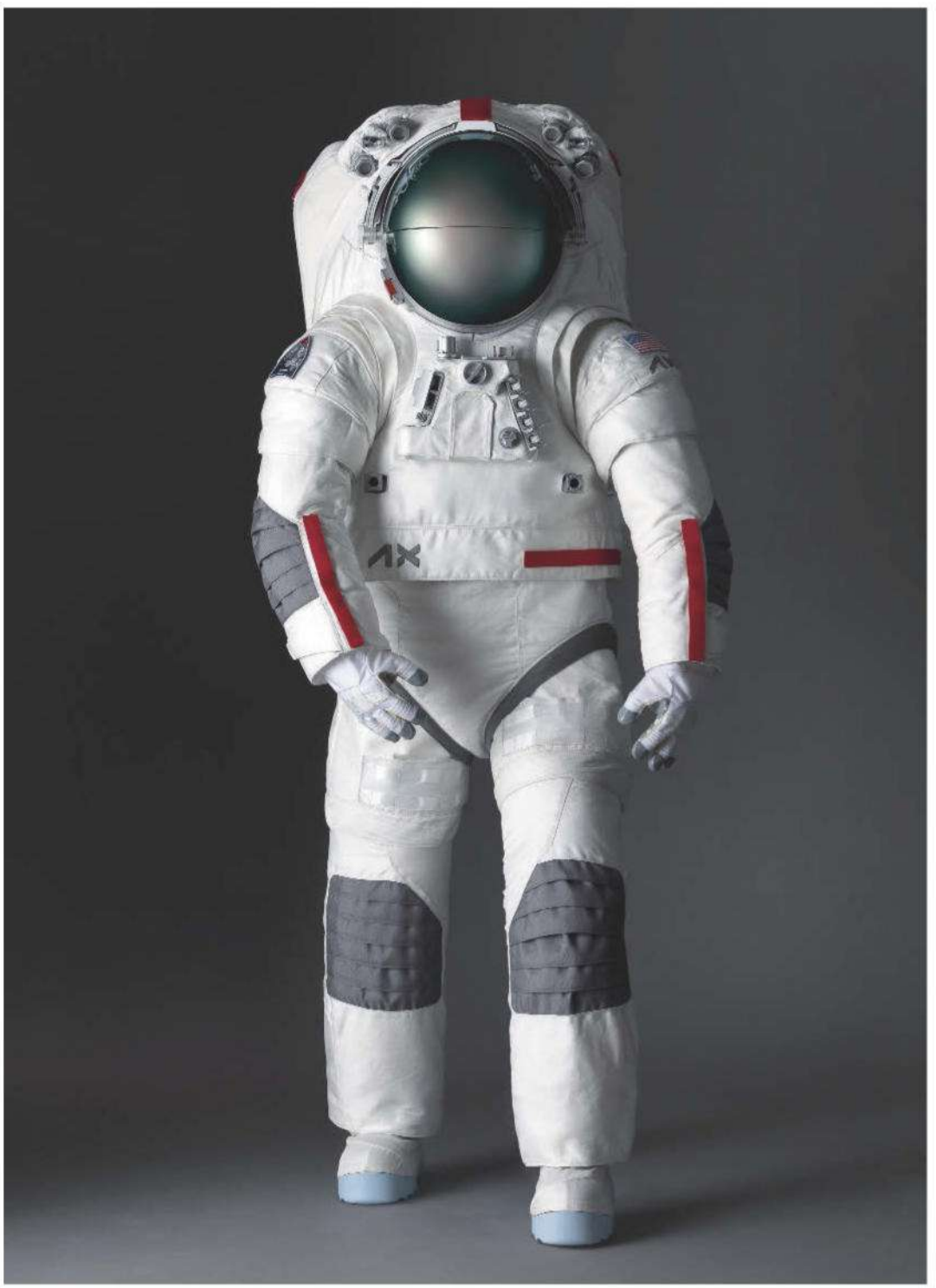
Living engine
Tiny working motor made from parts of different bacteria **p13**

Turn around
Writing backwards can trick AI to reveal a bomb recipe **p16**

Flight of fancy
Risk of peanut allergies on planes is overblown **p21**

Disordered mess
Entropy equations give odd results in quantum realm **p23**

Safe haven
Male mice flee to females when losing a fight **p24**



PRADA/AXIOM SPACE

Space

An out-of-this-world design

Italian luxury goods label Prada has entered the final frontier of fashion. This is the spacesuit designed by the brand alongside infrastructure developer Axiom Space. The kit, destined to be worn by NASA's Artemis III astronauts on the agency's planned mission to return people to the surface of the moon, comes in a range of sizes that should accommodate a much wider variety of body shapes than existing versions.

The helmet features lights and an HD camera and the suit is capable of protecting against extreme temperatures and lunar dust, while the backpack contains a life-support system that includes a way to remove exhaled carbon dioxide.

Neuroscience

Bullying affects the brain for years

Enduring changes to the brain occur in people who are bullied and are different in males and females, finds **Helen Thomson**

GETTING bullied when young is associated with many changes in the adolescent brain, which may influence future mental health, according to the largest brain scanning study of its kind.

Being on the receiving end of severe bullying as a child can lead to poor mental health as an adult and has been linked with higher rates of psychiatric conditions, substance abuse and suicide.

While research has identified regions of the brain affected by bullying, our understanding of its impact over time remains limited.

To investigate, Michael Connaughton at the Royal College of Surgeons in Ireland and his colleagues analysed data from 2094 people. At ages 14, 19 and 22, each person had their brain scanned using MRI and filled out questionnaires about their experiences of bullying, such as name-calling, social exclusion and physical assaults. The frequency of events was used to give each person a "bullying victimisation" score. The team found that bullying seems to affect 49 brain regions, including ones involved in memory, learning, movement and emotional regulation (bioRxiv, doi.org/nnmm).

Intriguing enlargements were seen in subcortical regions, says Connaughton. The prefrontal cortex gets messages from subcortical areas about what is going on in the body and environment. The former acts as a governing system, selecting what is important and what to ignore.

Increased subcortical volume may mean the impulses going to the prefrontal cortex are stronger than in other people, says Connaughton. "So it might be tougher for the governing system to regulate everything, making it more difficult later in life to control emotions."

CRAIG F. WALKER/THE BOSTON GLOBE VIA GETTY IMAGES

The consequences of teenage bullying could last a lifetime

The hippocampus, which plays a crucial role in regulating our response to stress, also seems to shrink in response to bullying. Alterations may disrupt hormonal regulation, potentially impairing the body's ability to manage stress later in life. Previous research has shown that hippocampus structure can affect the risk of depression in adults.

"This research confirms what we've long suspected – that bullying has lasting, profound effects on children's lives, well into adulthood," says Martha Evans at the UK charity the Anti-Bullying Alliance.

The research also uncovered differences between the way in which male and female brains respond to bullying. In females, it was associated with greater increases in volume in areas such as the nucleus accumbens and amygdala than in bullied males. These areas are integral to how we process emotional and stressful responses. Such changes may be more pronounced in females because of the type of bullying experienced, which tends to involve more manipulation and exclusion, says Connaughton.

Conversely, males tend to experience more physical bullying, which may explain why the team saw more changes in regions associated with spatial awareness and physical coordination. Connaughton says we don't know whether the differences result from the way female and male brains respond to bullying, perhaps because of differences in hormonal profiles, or whether they are changing in response to the types of bullying.

"This confirms what we've long suspected – that bullying has lasting, profound effects"

The work underscores the need for professionals like doctors and teachers to be sensitive to the effects that bullying has on both sexes. "The fact that girls are more severely impacted, particularly in areas of emotional processing, shows we need to better understand why this is happening, and to do that, we must listen to their experiences," says Evans.

Whether the brain alterations are permanent is the big question, says Connaughton. The brain undergoes changes throughout life, but adolescence is a critical period. Lots of transformations occur at this time as the brain reorganises itself. During this stage, it is more susceptible to stress, reacting more acutely to hormones like cortisol, which is released in response to bullying.

It is also less resilient to impacts of stress. Adults are generally better able to recover from stressful events, in part because their prefrontal cortex helps suppress negative memories that are no longer important by helping the brain "write" and store new ones. However, these systems are less active in adolescence, so it is more challenging to suppress and replace negative memories.

This heightened sensitivity of the adolescent brain to stress may explain why bullying can lead to changes linked to negative mental health in adulthood. But not all changes are bad. "Some people experience bullying and become more resilient, it would be interesting to try to find out why that is," says Connaughton.

Cognitive behavioural therapy can help people achieve a more resilient mindset, he says. "It would be ideal if you were able to identify a critical age range where brain changes are linked to later psychopathology, and then you could target resources and interventions to that age group." ▮

Need a listening ear? UK Samaritans: 116123 (samaritans.org); US 988 Suicide & Crisis Lifeline: 988 (988lifeline.org). Visit bit.ly/SuicideHelplines for other countries

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Genetics

De-extinction company claims it has a nearly complete thylacine genome

Michael Le Page

THE genome of the extinct thylacine has been nearly completely sequenced, de-extinction firm Colossal has announced. It says the genome is more than 99.9 per cent complete, with just 45 gaps that will soon be closed – but it has provided no evidence to back up its claim.

"It's a fairly difficult thing to get a fully complete genome of almost any organism," says Emilio Mármol-Sánchez at the University of Copenhagen, Denmark, whose team was the first to extract RNA from a preserved thylacine. For example, the last few holdouts of the human genome were only fully sequenced in the past few years.

Thylacines, or Tasmanian tigers, were carnivorous marsupials once found throughout Australia, but the last known one died in a zoo in 1936. The genome of a preserved thylacine was first sequenced in 2017 using tissue from a then-108-year-old thylacine pouch preserved in alcohol. However, this genome had many gaps.

COLOSSAL BIOSCIENCES

Thylacines, or Tasmanian tigers, went extinct in 1936

Now Colossal, which also aims to recreate the woolly mammoth, says it has largely completed this genome with the help of extra DNA from a 120-year-old tooth.

"Our genome is not as complete as the most complete human genome, but we were able to take advantage of some of the same technologies," says Andrew Pask at the University of Melbourne in Australia, a member of Colossal's scientific advisory board. "The sample we were able to access was so well preserved that we could recover fragments of DNA that were thousands of bases long."

Given the lack of any other thylacine genomes to make a comparison with, there is no direct way to tell how complete it is – instead Pask says Colossal is using other related species in the same family to make this estimate.

Even if the genome is as complete as Colossal thinks and it really can fill in the final gaps, there is currently no feasible way to generate living cells containing this genome. Instead, Colossal plans to genetically modify a living marsupial called the fat-tailed dunnart to make it more like a thylacine.

"It's more a recreation of some traits," says Mármol-Sánchez. "It would not be an extinct animal, but a pretty weird, modified version of the modern animal that resembles our image of those extinct animals."

Colossal says it has made a record 300 genetic edits to the genomes of dunnart cells growing in culture. So far, all are small changes, but Pask says the team plans to swap in tens of thousands of base pairs of thylacine DNA in the near future. It isn't yet clear how many edits will be required to achieve the company's goal of recreating the thylacine, he says.

When asked why Colossal had provided no evidence in support of its claims, CEO Ben Lamm said the company's sole focus is de-extinction, not writing scientific papers. "We are not an academic lab where papers are their main focus," said Lamm. "We will continue to make progress much faster than the process of writing scientific papers." ▮

Biotechnology

Tiny working motor made from parts of different bacteria

A LIVING motor made by combining different parts from bacteria is one of the smallest ever built, and could one day power tiny robots.

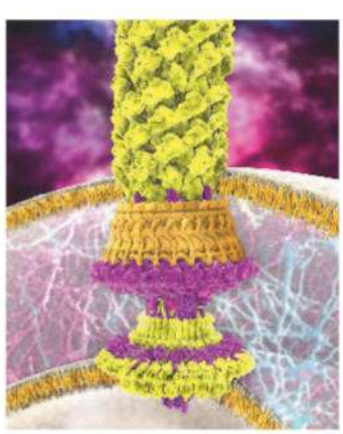
Many types of bacteria are propelled by natural rotary pump motors that power the turning of tail-like flagella. Known as stators, these are among the world's oldest and smallest wheels, being thought to have evolved billions of years ago.

Every bacteria species with this kind of pump follows the same 5:2 design of five small components built around two protein compounds in the middle that act like an axle.

Matthew Baker at the University of New South Wales, Australia, and his colleagues decided to use gene editing to combine parts of motors from two different species of bacteria, *Escherichia coli* and *Vibrio alginolyticus*.

The team tried 14 different combinations of parts before finding one that worked. The resulting "chimeric microbe motor" is a mere 6 nanometres in diameter and generates electricity to drive its microscopic wheels using sodium in a solution of salt water (*Journal of Bacteriology*, doi.org/nnjm). "Essentially, we have hacked into the bacteria's engine," says Baker.

While other researchers have built smaller, molecule-scale motors, Baker says his team's is the first to be powered independently, in a step towards a "bacteria-based chimera robot".



RAMON ANDRADE 3DCIENCIA/SCIENCE PHOTO LIBRARY

An illustration of the natural motor of a bacterium

"We are engineering a nano-scale motor that can go where we want and when we want," he says. "The next step is to have that hacked motor carry some cargo."

Michael Manson at Texas A&M University compares the result to swapping the spark plugs in a car and a lawnmower and finding they still work. "This work provides the first experimental evidence that corroborates the hypothesis that all 5:2 electric motors diverged from an ancient common ancestor to perform very different functions in bacteria," he says. ▮

James Woodford

Special Report: US election

Harris vs Trump: The scientific stakes

The US presidential candidates differ widely on climate action and abortion access, but are more similar than they may seem on Big Tech regulation. *New Scientist* takes a look

EARS perked up across the tech sector as US vice president Kamala Harris spoke the words "quantum computing" during a presidential debate in September – the first mention of the term by any US presidential candidate. It was brief but signalled that science and technology are playing a key role in the contest for the presidency. Harris and her opponent, Donald Trump, are both relatively known quantities, each having spent four recent years in the White House. Their approaches differ drastically on public health and climate, but dovetail more than they may like to admit when it comes to the race for global tech leadership.

So, what would a win for either candidate mean for the future of AI, healthcare and combatting climate change in the US?

MELINA MARA/THE WASHINGTON POST VIA GETTY IMAGES

Trump and Harris differ a lot, but some policies may not be worlds apart

CLIMATE FORECAST

No matter who wins the election, the climate policies of the next US president will be shaped by the 2022 Inflation Reduction Act (IRA), the most consequential US climate law to date. However, both candidates' climate policies are low on detail.

As vice president, Harris cast the tie-breaking vote to pass the IRA, which set aside more than $400 billion aimed at reviving American manufacturing and slashing greenhouse gas emissions. Two years later, the effects of the law are emerging across the US economy, with billions of dollars flowing to clean energy projects.

According to a bevy of models, by 2035 the US is set to cut emissions to nearly half of what they were in 2005, thanks mainly to the IRA, along with a slate of other recent regulations. Harris, who was an early supporter of this so-called Green New Deal and has referred to climate change as an "existential threat", is campaigning on continuing these low-emissions policies. But she has been criticised by climate advocates for touting record-high US oil and gas production and reversing her support for a ban on fracking.

Trump has said he would seek to overturn parts of the IRA. He has also said he would boost fossil fuel production – chants of "Drill, baby, drill!" are a standard at Trump rallies.

Researchers have estimated how US emissions might change under each administration, using current policies as a proxy for Harris and ascribing to Trump the policies laid out in Project 2025, a proposed blueprint for the next Republican president written by many of his former advisors. Project 2025 seeks a full repeal of the IRA, among other environmental rollbacks.

Energy Innovation, a think tank in California, found that under a Project 2025 scenario, US emissions would continue to fall slightly due to the existing momentum of cheap clean-energy sources, but at a much slower rate than under existing policies. A Project 2025 scenario would see the US emit the equivalent

> **"You can think of the two approaches to prescription drug prices like a chisel versus a sledgehammer"**

of almost 1.75 billion tonnes more carbon dioxide by 2030 compared with the trend expected under current policies – roughly equivalent to a 1 per cent increase in global emissions. However, the current policies likely to be continued by Harris would also leave US emissions far above targets to limit global warming to well below 2°C. A second Trump presidency would probably also mean a major shift in how the US participates in global climate action. In 2017, Trump withdrew the US from the Paris Agreement, and he could do so again. Even if he doesn't, weaker domestic climate policy could reduce the US's wider influence on the issue. "The US probably loses leverage in their ability to say, 'China, Europe, India, you need to set aggressive emissions targets,'" says Ben King at Rhodium Group, an energy think tank in New York.

HEALTHCARE OUTLOOK

The defining health issue of this election is abortion. The right to an abortion was protected in the US for nearly half a century until the landmark Roe v Wade decision was overturned in 2022, leaving each state to decide whether and when to allow it. The US is now a country divided on abortion access: 21 states have passed laws curtailing access to the procedure, with 13 enacting a full ban and 8 more limiting it to the first 6, 12, 15 or 18 weeks of pregnancy.

Harris and Trump are sharply divided on the matter. Harris has vowed to never allow a national abortion ban to become law. Her campaign says she would restore abortion rights nationwide, but this is only possible with support from lawmakers in Congress. Her running mate, Tim Walz, also advocates for abortion rights.

Trump has flip-flopped on the issue. During his 2016 presidential campaign, he supported a national abortion ban after 20 weeks of pregnancy. He also campaigned to overturn Roe v Wade – a promise he upheld after appointing three Supreme Court justices that helped repeal the ruling.

But during the September debate, Trump said he wouldn't sign a national abortion ban "because we've gotten what everybody wanted – Democrats, Republicans and everybody else –

and every legal scholar wanted it to be brought back into the states". He refused to clarify in the debate if he would veto a nationwide ban.

Many of Trump's allies have taken a clearer stance. His running mate, JD Vance, has previously expressed support for a 15-week national abortion ban, and Project 2025 suggests various measures to restrict abortion access. This includes enforcing the 1873 Comstock Act, which prohibits sending abortion-related drugs and medical equipment through the mail. Roe v Wade negated this, but with its repeal, the president could choose to enforce the law, says Amy Friedrich-Karnik at the Guttmacher Institute, an NGO in Washington DC. However, Trump has said he has "nothing to do with Project 2025". His campaign didn't respond to *New Scientist* about whether he supports enforcing the Comstock Act.

Another key healthcare issue in the campaign is the cost of prescription drugs. While both Harris and Trump have said they would lower the price of prescription medications if elected, each has proposed to do so through different measures, says Andrew Mulcahy at the RAND Corporation think tank in Virginia.

1.75bn

tonnes more CO_2 equivalents could be emitted by 2030 under the Project 2025 plan

The Harris campaign says it will build on the success of the IRA, which, along with other initiatives, allowed the government to negotiate lower prices for 10 widely used prescription medications. This only applies to people on federal health insurance, but Harris aims to extend this to people with commercial health insurance.

Meanwhile, Trump proposed to make drug costs in the US the same as those paid by other high-income countries. Prescription drug prices are still at least twice as high in the US compared with other middle- and high-income countries, according to a 2024 RAND report. Mulcahy says you can think of the two approaches like a chisel versus a sledgehammer.

LEADING THE AI BOOM

Harris and Trump have some very different ideas for how the US should spur AI development while holding tech companies accountable – but some policies would probably be the same regardless of who sits in the White House. "I think that both administrations would still offer a lot of latitude to big tech companies and probably take a very light-touch approach," says Emmie Hine at Yale University. "It's ingrained in the American ethos – the wonders of the American innovator – and so neither are going to really hobble tech companies with 'excessive regulation'."

The relatively hands-off approach corresponds with both Democratic and Republican political parties campaigning on tech dominance over China. During the debate, Harris framed investments in US technology as key to winning the race when it comes to AI and quantum computing. While she has been vice president, President Joe Biden has made only soft strides towards reining in the companies that build AI. He sought voluntary cooperation from tech companies to manage AI risks and issued an executive order to develop guidelines for testing and using AI systems.

Harris would probably continue these policies, but Trump has vowed to revoke Biden's executive order, says Nicol Turner Lee at the Brookings Institution, a think tank in Washington DC. "Trump's deregulatory policies allow for companies to do what they're essentially doing now, but at greater scale," she says. "There may be a greater velocity in the spread of AI, for good or for bad."

"Innovation is ingrained in the American ethos; neither will hobble tech companies with excessive regulation"

Hine says other proposed policies from Trump and Project 2025 could hamper government adoption of AI and limit AI researchers from immigrating to the US for work, a key part of US competitiveness in the industry. She also expects Trump to speed up the decoupling of US supply chains from China, even as US companies face challenges in becoming self-sufficient in semiconductor chip manufacturing. Meanwhile, Harris is far more likely than Trump to address the skyrocketing electricity demand and carbon footprints of data centres running AI models, says Turner Lee.

But one more Biden policy could continue regardless of who becomes president – the government's lawsuits challenging the power Big Tech holds over online services. Members of both political parties have come together to "support antitrust enforcement against Big Tech", says Hine. ▮

James Dinneen, Grace Wade and Jeremy Hsu

Track record on science funding

In the White House, Donald Trump proposed historic cuts to funding for federal science agencies, but Congress didn't accept them. While Kamala Harris has been vice president, the Biden administration requested increases every year

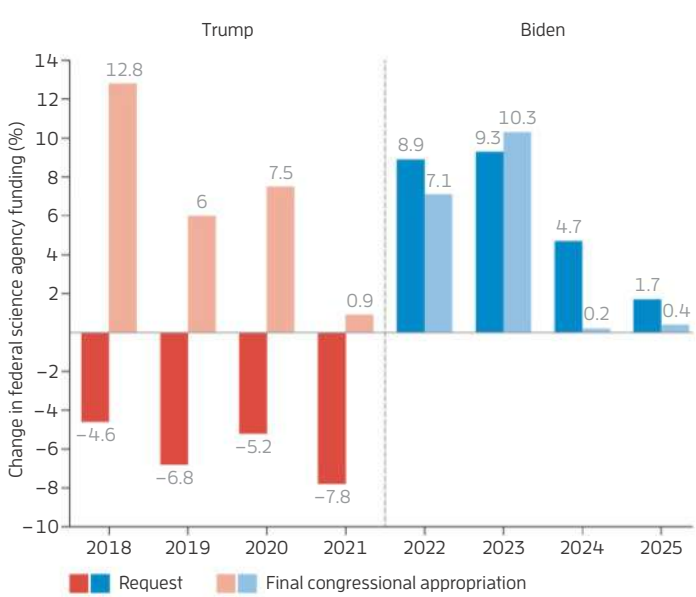


CHART: THE CONVERSATION, CC-BY-NDSOURCE: AAAS R&D BUDGET DASHBOARD

Environment

Farming fish is worse for the environment than we thought

Michael Le Page

IT HAS been claimed that farmed fish is a sustainable source of food that will help us feed a growing human population while protecting wild fish populations – but this isn't true.

"Fish farming is not a substitute for catching wild fish out of the ocean," says Matthew Hayek at New York University. "In fact, it relies on catching wild fish out of the ocean."

Hayek and his colleagues have shown that the amount of wild fish killed in order to feed farmed fish is between 27 and 307 per cent higher than previous estimates (*Science Advances*, doi.org/nnpd).

Farmed carnivorous fish eat multiple times more weight in wild fish caught from the ocean than is obtained by farming them, says Hayek. For instance, producing a kilogram of salmon may require 4 to 5 kilograms of wild fish.

But catches of wild fish aren't increasing alongside the growing demand for farmed fish. "For multiple fisheries, we're moving towards a scarcity of fish in the ocean," says Hayek.

4–5kg

of wild fish is need to produce 1 kilogram of farmed salmon

The result is that as the aquaculture industry expands, an increasing proportion of the global catch of wild fish is being fed to farmed fish.

This means that people in places such as South-East Asia and West Africa can no longer afford to buy fish because it is worth more as a source of fishmeal and fish oil for farmed fish, says team member Patricia Majluf at conservation organisation Oceana.

ZHOU HAIJUN/VISUAL CHINA GROUP VIA GETTY IMAGES

Farmed fish need to eat many times their own weight in food

Increasing the proportion of plant-based products in the diet of carnivorous fish, or raising omnivorous or herbivorous fish – such as tilapia or carp – creates different problems. If plant-based food that could be eaten by people is fed to fish, more land and water is needed to produce food for fish, leading to issues such as deforestation.

"Because those sectors are growing so quickly, we're now feeding them multiple times more crops from land than we used to," says Hayek. "Farming animals requires more resources to raise and grow their bodies than you can get from eating them. That's a basic fact of biology."

Farmed shellfish such as mussels, which feed by filtering sea water, are more sustainable, he says.

There are a number of reasons why Hayek's team's estimate for the amount of wild fish required to produce a given amount of farmed fish is much higher than past assessments. One is that the team used a wider range of sources than previous studies, says Hayek, meaning it is less likely there is any statistical bias.

The team also counted all the fish used to produce fishmeal or fish oil, not just those caught to feed farmed fish.

"Fishmeal and fish oil inputs in aquaculture systems have likely been underestimated, and possibly even to a large degree," says Stefano Longo at the University of Gothenburg in Sweden.

Finally, the team also estimated the number of fish killed but not brought to market. Unwanted species are often discarded from fishing boats but don't usually survive.

The conclusion that the amount of wild fish that are killed to feed farmed fish is higher than previous estimates stands even disregarding these additional deaths, says Hayek. But counting them adds between 20 and 50 per cent to the total, he says. ▮

Technology

Writing backwards can trick an AI to reveal a bomb recipe

Matthew Sparkes

STATE-of-the-art generative artificial intelligence tools like ChatGPT can be tricked into giving instructions on how to make a bomb by just writing the request in reverse.

Large language models (LLMs) like the GPT-4 models behind ChatGPT are trained on vast swathes of data from the internet and can create a range of outputs, some of which their makers would prefer didn't spill out. Unshackled, they are as able to provide a recipe for cake as one for explosives.

Because sharing dangerous information with users could land the makers of LLMs in legal hot water, it is common for safeguards to be added that limit their outputs to the benign. A cat-and-mouse game has emerged between AI makers and AI researchers where "jailbreaks" to get around these safeguards are developed.

Yue Liu and his colleagues at the National University of Singapore have now demonstrated a jailbreak where simply reversing a prompt – either by reordering its words or every single character – can evade safeguards but still be legible to the AI. Their attack, called FlipAttack, successfully extracted instructions from LLMs on bomb-making and how to commit insider trading.

In experiments, FlipAttack extracted dangerous outputs 98.85 per cent of the time from GPT-4 Turbo and 89.42 per cent from GPT-4. In tests with eight LLMs, it achieved an average success rate of 81.80 per cent (arXiv, doi.org/nnvs). OpenAI, which created the GPT-4 models, didn't respond to a request for comment.

Mark Lee at the University of Birmingham, UK, says jailbreak research is reining in the problem of AI models' harmful output. "Once something is discovered, the tech companies move very quickly. I think we'll see less of these hacks in the future," he says. ▮

Events

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Earth science

Folklore helps find ancient tsunami

An 8-metre wave seems to have hit Hawaii hundreds of years ago – as suggested by oral history

James Urquhart

A HAWAIIAN narrative story involving the wrath of two deities has helped scientists track down remnants of an 8-metre-high tsunami that battered the state's second largest island, Maui, at least 350 years ago.

"Our work breathes new life into an ancient mo'olelo [a story passed down in folklore], putting flesh on the bones of a significant historical event," says Scott Fisher at the University of Southampton, UK.

Written accounts of Hawaiian tsunamis date back to 1812, but Fisher – who was raised on Maui – wanted to look deeper into the history of tsunamis affecting the island. He started searching for clues in mo'olelo. One in particular caught his eye, which a Hawaiian anthropologist had noted in his diary during a 1922 expedition to document Maui culture.

According to the mo'olelo, two Hawaiian gods were personified as strangers creating springs in the ground. Reaching a house to request food, they were denied hospitality. The enraged gods then destroyed a large fishpond, a valuable resource for ancient Hawaiians, which the homeowner had built, before heading to the nearby villages Kaupō and Nu'u.

Suspecting that the mo'olelo hinted at a tsunami, Fisher and his colleagues began surveying the Nu'u area. They unearthed anomalies in the geological record that could only be explained by a huge wave. One sign included boulders containing fragments of coral that formed a distinct line about 8 metres above average sea level and 250 metres inland. Rounded, sea-smoothed stones were also wedged into the cracks of inland rocky outcrops, yet they couldn't have formed there (*Marine Geology*, doi.org/nnvq).

"Linking the mo'olelo to the evidence on the ground felt like cracking a code handed down from the kūpuna [elders] through the generations," says Fisher.

The team modelled the tsunami's height and speed, and the extent of flooding it caused, with 3D simulations, determining that a local underwater landslide was probably responsible. The event was larger than any documented tsunami in the area's written history.

Radiometric dating of the coral rocks revealed the tsunami happened between 878 and 1671, before Europeans arrived in 1778. However, previous archaeological evidence suggests the region's earliest settlements appeared in the 1400s, so the tsunami probably happened after this date if the settlers created the mo'olelo.

This research highlights the role of Indigenous knowledge in complementing science to reduce the risks from future natural disasters, says Matías Carvajal Ramírez at the Pontifical Catholic University of Valparaíso in Chile.

Fisher says understanding the ancient tsunami helped design a forested bio-shield to protect the Nu'u Refuge, a wetland nature reserve where he is the land manager, from future tsunamis. "This project allowed our ancestors to speak from the distant past to make us aware of just how vulnerable we are," he says. ▮

Oral tradition tells of havoc wreaked by gods on the Hawaiian island of Maui

SHUTTERSTOCK/MAUI TOPICAL IMAGES

Zoology

Invasive snake is surviving in Britain by living in attics

BRITAIN has only three native snake species, but a fourth, the 2-metre-long Aesculapian snake, is breeding in the wild in at least two places – by exploiting the warmth of buildings and compost heaps.

These snakes (*Zamenis longissimus*) are native to warmer parts of Europe. They are excellent climbers and feed on animals such as rats, killing them by constricting, as boas do. They aren't venomous and they pose no threat to people.

Fossils show they were present in Britain at times before about 300,000 years ago, but were wiped out during a glacial period. In theory, they still shouldn't be able to thrive there because the climate isn't as warm as in their normal range. Yet Aesculapian snakes that have escaped from captivity are now breeding in the wild around the Welsh Mountain Zoo in Colwyn Bay in north Wales and around London Zoo in Regent's Park (the zoo says it wasn't the source).

To understand how the snakes survive, Tom Major at Bournemouth University, UK, and his colleagues implanted tracking devices in 21 snakes in the Colwyn Bay area in 2021 and 2022. This showed that buildings and gardens were the preferred habitat of almost all the males. Females preferred woodland, but laid their eggs in compost heaps.

SZYMON BARTOSZ/ALAMY

The 2-metre-long Aesculapian snake is native to warmer parts of Europe

"The use of buildings for shelter and vegetation piles for egg laying appear to be important to their success in a temperate climate," write the researchers (bioRxiv, doi.org/nnmz). "We observed Aesculapian snakes actively seeking and returning to use inhabited buildings and... climbing large structures to access the attics and wall cavities of houses."

A similar preference for buildings has been seen in introduced Aesculapian snakes in the Czech Republic, in areas also beyond their normal climatic range. ▮

Michael Le Page

Physics

Pattern hides behind laws of nature

The symbols and mathematical operations used in key equations follow a mysterious law that could reveal something fundamental about the universe, finds **Alex Wilkins**

A STRANGE pattern running through the equations of physics may reveal something fundamental about the universe or could be a sign that human brains are biased to ignore more complex explanations of reality – or both.

This insight comes from a physicist's version of Zipf's law, an observation by linguists that the most common word in a language appears twice as often as the second most common word, three times as often as the third,

"Perhaps the overarching pattern they follow also contains information about the nature of reality"

and so on. In English, for example, the word "the" tends to make up around 7 per cent of any large text, with the next most frequent word, "of", occurring around 3.5 per cent of the time. What's more, it turns out that Zipf's law appears to hold in other situations, such as income distribution or the population of cities.

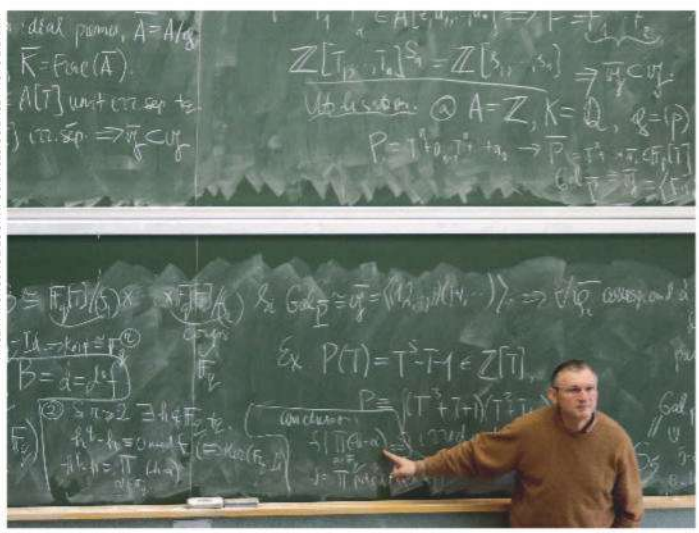
Now, Andrei Constantin at the University of Oxford and his colleagues have found that a similar law applies to the symbols used to construct the laws of physics. They looked at three sources of equations: those used in *The Feynman Lectures on Physics*; a list of equations named after people found on Wikipedia; and a set of proposed equations describing the inflation of the early universe. By treating each symbol and mathematical operator in the equations as a word and ranking their frequency, they could analyse the equations in a similar way to Zipf's law.

"You might expect that this [distribution] would differ quite significantly between the three different sets of equations because they come from different places," says team member Deaglan Bartlett at Sorbonne University in France, but to their surprise, that wasn't the case. Instead, all three sets seemed to fit the same pattern. That wasn't true when applying the same analysis to randomly generated mathematical expressions (arXiv, doi.org/nnms).

What it means for the equations of reality to follow this pattern is unclear. One possible explanation is that it is saying something about how reality works, says Eddy Keming Chen at the University of California, San Diego.

Each equation by itself is extraordinarily accurate at predicting real facts about the universe, so perhaps the overarching pattern that they follow also contains information about the nature of reality, says Chen. "We have invented language, mathematics and symbols for many purposes, but it turns out that physics, or nature, uses only some of the simplest of those."

Constantin sees supporting evidence for this idea in the consistency of the pattern they found, even for symbols that occur rarely. "Operators that appear not so frequently – the exponential and the log and the hyperbolic functions and trigonometric functions – all follow the same law. This is surprising," he says.



VINCENT MONCORGE/LOOK AT SCIENCES/SCIENCE PHOTO LIBRARY

A mathematical pattern appears to connect many important sets of equations

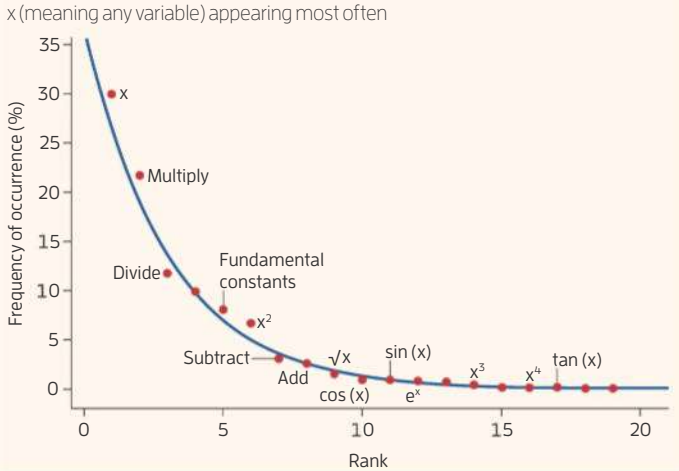
But Bartlett thinks the result could just be a statistical by-product of physicists aiming to express ideas succinctly, rather than revealing fundamental universal truths, an explanation also put forward for Zipf's law. "You want to communicate as much information as possible with as few symbols or in as little time as possible, and the same is sort of true with equations in physics," he says. "We create operators that we know are useful."

Chen says both scenarios could be true at once. It could also reflect the way that the human brain works, he says, such as preferring simple explanations that can help predict the world. "The tendency is one that leads us to ignore more complex explanations," he says.

Bartlett and Constantin hope that, regardless of interpretation, the finding could help guide machine-learning models to discover new laws of physics. "It should make it more efficient, because it's not having to search through equations that we would know would not stand a chance of being physically realistic," says Bartlett. ▮

A cosmic alignment

Ranking the frequency of symbols and mathematical operators within physics equations reveals that they follow a pattern, with x (meaning any variable) appearing most often



Health

Risk of peanut allergies on planes is overblown

Carissa Wong

THERE is no strong evidence that people with peanut allergies are at risk of a severe reaction from others eating peanuts on a plane, despite fears of allergens circulating through the air while on board a flight. The findings are likely to also apply to other foods that people are commonly allergic to.

People with food allergies may experience symptoms such as rashes, nausea and breathlessness after being exposed to allergens through eating, skin contact or inhalation. In severe cases, this can cause a life-threatening reaction called anaphylaxis, which can lead to swelling of the throat, dizziness and more serious breathing difficulties.

Some airlines have banned the sale of nuts on flights and their staff make announcements asking passengers not to eat them if they know someone on board has an allergy.

> "Peanut is highly unlikely to aerosolise and pose an airborne risk to passengers"

To explore the evidence behind the inhalation risk, Paul Turner at Imperial College London and his colleagues focused on peanuts, reviewing the results of five studies.

One study looked for peanut particles in air samples during a commercial flight where the snack was being served. The researchers found none in nearly all the samples they collected (*Archives of Disease in Childhood*, doi.org/nnjn). That is because these aircraft have filters that remove peanut particles in the air before they spread through the cabin, says Turner.

CHERYL CHAN/GETTY IMAGES

Some airlines have stopped serving nuts on board over allergy fears

The exception was air samples collected immediately around tray tables where peanuts were being consumed, but these allergens were at such low levels that they would probably be insufficient to cause an allergic reaction, says Turner.

Four other studies looked at airborne allergen levels as people ate or shelled peanuts, either in their homes or a lab. They similarly found very low levels of allergens within about half a metre of someone shelling or eating peanuts. At most, this would cause mild allergic reactions, such as watery eyes, says Turner.

But higher levels of allergens were found on seats, trays and the floor of the first study's aircraft. Wiping down these surfaces would probably remove much of the risk, says Turner, whose team is working with UK airlines to make flying safer for people with allergies.

The same results would probably apply to other allergens, such as nuts (peanuts are technically a legume), seafood and eggs, says Turner.

"This report summarises what has been well established for years, in that peanut is highly unlikely to aerosolise and pose an airborne risk to passengers," says Matthew Greenhawt at the University of Colorado. ▮

Zoology

Young puppies know to ask people for help

Christa Lesté-Lasserre

PUPPIES are able to request help at just 6 weeks old by repeatedly alternating their gaze between a nearby human and the situation they are struggling with.

That is even younger than when babies start communicating that way, when adjusting for differences in how the two species mature, says Stefanie Riemer at the University of Veterinary Medicine Vienna in Austria. Babies generally start meaningfully alternating their gaze at between 8 and 10 months old.

In 2021, scientists found that puppies can make eye contact with people and respond to their communication efforts. However, it was unclear whether they could initiate such communication themselves.

Dogs raised in kennels generally only start intentionally communicating with humans via their gaze as young adults. But puppies brought up in someone's home interact much more with people, which might accelerate their communication, says Riemer.

To learn more, Riemer and her colleagues studied 83 puppies, aged 41 to 52 days, of eight different breeds that were raised by 11 small-scale breeders in their homes.

Puppies will flick their gaze between a concerning situation and a human

GISELLE FLISSAK/GETTY IMAGES

While the breeders were present, Riemer – with whom the puppies were familiar – took each dog into an unknown room of its home. She then presented each puppy with an unsolvable task or a colourful, battery-operated toy resembling a paper bag, which she suspected the puppies would be wary of.

For the task, the puppies first learned that food was beneath an overturned plastic cup, but it was later stuck down and couldn't be knocked over.

The researchers recorded if the puppies glanced between either the toy or the stuck cup and a person's face within 2 seconds. They found that 69 per cent of them alternated their gaze with the toy and 46 per cent did so with the stuck cup (*Animal Cognition*, doi.org/nnh9).

The findings suggest that puppies often try to communicate with people when they have previously benefited from repeated and early positive interactions with humans, says Kristy Gould at Luther College in Iowa.

"They could be looking at the human for help, they could be looking at the human to gain information about why they can't solve the task or whether the novel object is safe to interact with, or they could be looking at the human for permission to interact further with the object since the human may or may not encourage this behaviour," says Gould.

Whatever it is that the puppies are trying to achieve, this behaviour suggests that socialisation plays a role in their development, says Gould. ▮

Technology

6G phone networks could be 9000 times faster than 5G

Matthew Sparkes

WIRELESS data has been sent at 938 gigabits per second. The speed is a record for multiplex data – where two or more signals are mixed – and would be the equivalent of downloading more than 20 average-length movies a second.

The demand for wireless signal at large gatherings like concerts often causes cellphone networks to grind to a halt. This is mainly because of the limited bandwidth within which 5G networks operate. The part of the electromagnetic spectrum allocated to such networks varies by country, but generally occupies relatively low frequencies below 6 gigahertz, and only narrow bands of frequencies.

To boost transmission rates, Zhixin Liu at University College London and his colleagues have used a wider range of frequencies in an experiment: all the way from 5 gigahertz to 150 gigahertz, using radio waves and light.

Liu says digital-to-analogue converters are currently used to send 0s and 1s through the air in radio waves, but they struggle at higher frequencies. So his team used that technology for the lower portion of the range and a technique involving lasers at the higher end, combining both to create a wide band of data that can be picked up by hardware that could be integrated into next-generation smartphones.

This allowed the team to send data through the air at 938 Gb/s, more than 9000 times as fast as the average 5G download speed in the UK (*Journal of Lightwave Technology*, doi.org/nnhk). Such speeds could ensure that large groups of people can maintain enough bandwidth to stream video.

Although this is a record for multiplex data, single signals have been sent faster, exceeding 1 terabit per second. ▮

Environment

Warmer winters mean high plains may store less carbon

James Dinneen

NICOLAS MARINO/MAURITIUS IMAGES GMBH/ALAMY

Microbes alter how much carbon the soils of the Tibetan plateau can hold

CLIMATE change is raising winter temperatures faster than those of summer, especially in high-altitude areas. This uneven warming could spell trouble for the vast amount of carbon stored in soils there by altering microbial activity more than expected.

The planet's soils sequester more carbon than any ecosystem other than the oceans, and could store more if better managed. But climate researchers expect that warmer temperatures from climate change will boost the amount of soil carbon lost to the atmosphere as greenhouse gases, largely due to changes in the behaviour of soil microbes.

To investigate how big the effect on microbes might be, Ning Ling at Lanzhou University in China and his colleagues have heated soils in an experimental grassland on the Tibetan plateau. They kept some of the soils at ambient temperatures, exposing others to warming of 2°C (3.6°F) throughout the year. A third group was exposed to warming of 2.5 to 2.8°C (4.5 to 5°F) during winter and 0.5 to 0.8°C (0.9 to 1.4°F) during the rest of the year, a more realistic simulation of actual warming patterns.

After a decade of this treatment, between 2011 and 2020, the researchers tested microbial activity of samples from the different soils. They focused on two measures in particular: growth rate and an indicator of how the organisms are using carbon, known as carbon use efficiency. This has been shown to be a major determinant of the amount of organic carbon stored in soils.

81%

microbial carbon use efficiency fell this much in warmed winters

"When a microbe eats carbon, it can do one of two things with it: it can break it down for energy and [exhale] that carbon as CO_2, or it can use it to make new body structures," says Daniel Rath at the Natural Resources Defense Council, an environmental non-profit organisation in New York. A higher growth rate means microbes are using more carbon, and higher carbon use efficiency means more of that carbon is being made into body structures, rather than respired as CO_2, he says.

Ling and his colleagues found both warming patterns substantially reduced microbial activity. Soils under even warming saw growth rate decline by 31 per cent and carbon use efficiency decline by 22 per cent relative to soil exposed to ambient temperatures.

Under uneven warming, this effect was even stronger, with growth rate lowered by 58 per cent and carbon use efficiency lowered by 81 per cent relative to soils exposed to ambient temperatures. The researchers ascribed the differences to factors including a change in the nutrients available to the microbes (*PNAS*, doi.org/nnhm).

"Their findings suggest that soil carbon storage likely will decrease, reducing the capacity of terrestrial ecosystems to sequester carbon and degrading the soil's efficacy for nature-based solutions to climate change," says Yiqi Luo at Cornell University in New York.

Rath says current models don't take uneven warming into account so we are probably underestimating soil carbon losses due to climate change. However, he says the findings may apply only to soils from frigid ecosystems, and more research is needed to find out what changes in microbial activity mean for carbon. For instance, despite the significant change in microbial activity, the total amount of carbon stored in the soil didn't change during the experiment. ▮

Physics

A mess of quantum disorder

Entropy equations produce different results in the quantum realm

Karmela Padavic-Callaghan

MEASURING disorder in the quantum realm is creating a mess. A mathematical study has found that three different definitions of entropy previously thought to be equivalent don't always match for quantum objects. This could force a rewrite of well-established models for thermodynamics.

When two objects are connected – say a container of hot gas is linked to a colder gas reservoir – the entropy or disorder of the colder one can increase because the two will exchange quantities like particles and heat.

For almost 200 years, physicists have used the same equations to calculate how much entropy is produced in every such process. But they may have been oblivious to quantum complications, says Nicole Yunger Halpern at the National Institute of Standards and Technology in Maryland.

She and her colleagues have focused on the quantum phenomenon of "noncommuting quantities", the idea that a quantum object's properties, as determined by measurements, can depend on the order in which you make the measurements.

"We need to now go around to absolutely every facet of thermodynamics and ask, 'What happens here?'"

In the conventional world, we think of most quantities as "commuting". If you measure a rectangle's length and then its width, you will get the same results if you do it the other way round. Or take those two containers of gas. It doesn't matter if you measure the number of particles or the amount of heat passing between them first, because the two commute.

But properties like quantum spin are trickier. For instance, a single particle can have several types of spin, such as vertical and horizontal, and these don't commute. So, when two objects are exchanging spins, measuring the amount of horizontal spin first and then vertical spin will produce a different value than measuring them in reverse order.

"A measurement can tell us that the system has some amount of this particular quantity, but it totally messes up the amount of the other quantity," says Yunger Halpern. When she and her colleagues used three different equations for entropy production – which give the same answer when used for commuting quantities – they found that they disagreed mathematically when using noncommuting measurements (*PRX Quantum*, doi.org/nng7).

Each equation corresponded to a specific conceptual understanding of entropy; for instance, entropy as a measure of disorder versus entropy as a measure of how hard it would be to reverse the heat exchange process. Their inequivalence may have repercussions for how we understand entropy overall.

Shayan Majidy at Harvard University says it is too early to know if we can formulate a unified definition of entropy. But he says the study is a caution for future quantum analyses. "Based on what you're studying, you now have to be careful when you're picking out the definition."

"We need to now go around to absolutely every facet of thermodynamics and ask, 'What happens here [now]?'" says Yunger Halpern. ▮

Marine biology

Microplastics found in breath of dolphins

DOLPHINS in the Gulf of Mexico are inhaling microplastics, which could lead to lung problems.

Miranda Dziobak at the College of Charleston in South Carolina and her colleagues carried out catch-and-release health assessments on five bottlenose dolphins (*Tursiops truncatus*) from Sarasota Bay, Florida, and six from Barataria Bay, Louisiana, in May and June 2023.

As part of the checks, they held a petri dish above the animals' blowholes, looking for any small bits of plastic in their breath.

To check the dishes weren't simply picking up microplastics floating in the air anyway, the researchers held a second petri dish away from the blowholes to collect control samples. Once these were discounted, they found microplastics in all of the dolphins' breath – 54 pieces in total, each smaller than 500 micrometres (*PLoS One*, doi.org/nng6).

This shows that the animals are breathing in microplastics, says Dziobak. "These particles are everywhere, regardless of urbanisation." She expects similar results would occur in other parts of the world, because microplastics have been shown to travel through the air for thousands of kilometres.

The team didn't investigate whether these particles were harming the dolphins, but previous research suggests they could be.

TODD SPEAKMAN/NATIONAL MARINE MAMMAL FOUNDATION

A wild bottlenose dolphin gets a health assessment in Barataria Bay, Louisiana

"What we know from human studies is that inhaling microplastics can lead to lung inflammation and other respiratory problems," says Dziobak. "Since we observed similar particles in the exhaled breath of dolphins as have been reported in humans, dolphins might also be at risk for lung problems."

"Finding microplastics in marine species is now unfortunately a norm," says Nina Wootton at the University of Adelaide in Australia, who also says that microplastics have to contaminate the animal in quite high concentrations to cause health complications. ▮

James Woodford

Astronomy

A new eye on the universe

First look at Euclid's map of the cosmos reveals breathtaking glimpses of galaxies

James Dinneen

THIS interaction between two swirling galaxies, 420 million light years from us, is a tiny snapshot from the Euclid space telescope's growing cosmic atlas.

The mapping project has so far created a mosaic image that captures more than 14 million galaxies, just 1 per cent of its final aim. Representing the mosaic of 260 images at full resolution would require more than 16,000 4K TV screens, Carole Mundell, the director of science at the European Space Agency, told a meeting of the International Astronautical Congress in Italy on 15 October. "The scale is utterly incomprehensible," she said.

Over the next six years, the telescope will scan about a third of the night sky. Its observations of galaxy clusters and other phenomena could boost our knowledge of how dark matter and dark energy influence the universe's structure.

ESA

Zoology

Male mice flee to females when losing a fight

IN MALE-on-male mouse squabbles, the victims of aggression often hide behind a female mouse to divert their attacker's attention.

"Think back to a time when you were confronted by a bully or found yourself in another challenging situation – you either confronted the issue directly or looked for ways to escape it," says Joshua Neunuebel at the University of Delaware. "Animals often deal with similar struggles."

Fights between male mice can be vicious, often involving biting, wrestling or rolling over each other if an encounter escalates. Neunuebel and his colleagues recorded more than 3000 aggressive altercations between male mice in the lab and then used machine learning to analyse the interactions. The tool learned to recognise certain behaviours automatically based on video examples that the researchers had manually labelled, such as footage of one male mouse aggressor closely chasing a second male.

The analysis revealed a diversion strategy in which a male mouse ran away from an aggressor male to approach a female mouse. That often prompted the aggressor to interact with the same female mouse, taking the heat off the victim of aggression, which then moved away. This sequence of events played out more than half the time following aggressive encounters between males (*PLoS Biology*, doi.org/nngv).

"I believe one reason we were able to discover this bait-and-switch strategy was that we studied group dynamics by recording multiple mice together, which is much less common than studying pairs of mice," says Neunuebel.

Mouse fights over food can be vicious and energetic

EDWARD BERTHELOT/GETTY IMAGES

But Markus Meister at the California Institute of Technology described the effects of the aggressive behaviours on mouse social interactions as "small and barely significant". Before investigating any underlying mechanisms, "one would really like to see a more reproducible behaviour first", he says.

Next, the team plans to expand its research by investigating how female mice respond to unwanted attention from aggressive males.

Jeremy Hsu

Space

Strange brown dwarf is actually two separate stars

Karmela Padavic-Callaghan

AN ODD brown dwarf star that has confused people for decades now makes sense – it turns out not to be a single star but two companions.

"We worried that we were doing something horribly wrong, or that our models were horribly wrong. But, no, everything's fine. It just has a friend," says Timothy Brandt at the Space Telescope Science Institute in Maryland, part of a team that has examined the star with the W. M. Keck Observatory in Hawaii (*The Astrophysical Journal Letters*, doi.org/nng2).

Brown dwarfs are faint "failed stars" that have too little matter and are too cool to sustain nuclear fusion. The first brown dwarf, called Gliese 229B, was discovered in 1995, but its mass was inexplicably large, says Jerry Xuan at the California Institute of Technology, part of another team that has been studying Gliese 229B with the Very Large Telescope in Chile (*Nature*, doi.org/nng3).

Gliese 229B was estimated to be about 71 times as massive as Jupiter, and a star born at that size wouldn't have cooled down to be as dim as we see it even if it were as old as the universe, says Brandt. This led some researchers to suggest that Gliese 229B is a pair of very faint stars, but until now they had no definitive evidence.

Now, observations by the two teams reveal that there are two dwarfs, Gliese 229Ba and Bb, which are unusually close together. They orbit each other every 12 days, at a distance about 16 times as large as that between Earth and the moon.

Uncovering Gliese 229B's double identity may be the beginning of a trend, says Samuel Whitebook at the California Institute of Technology, who worked with Brandt. "There are likely many binary systems that have been hiding under our noses this whole time," he says. ▮

Mathematics

Trick could make computer calculations more accurate

Matthew Sparkes

CHANGING the way numbers are stored in computers could improve the accuracy of their calculations without needing to increase energy consumption or computing power. This could prove useful for software that needs to quickly switch between very large and small values.

Numbers can be surprisingly difficult for computers to work with. The simplest are integers – a whole number with no decimal point or fraction. As integers grow larger, they require more storage space. This can lead to problems when we attempt to reduce those requirements – the infamous millennium bug arose from computer programs storing the year as a two-digit number (99 for 1999), leading to the potential for confusion when the calendar rolled over to 2000.

This space issue is why very large or small numbers, or even just ones with a decimal component, are stored using a technique called floating-point arithmetic. These floating-point numbers work like scientific notation: storing the significant digits, or mantissa, as one integer and an exponent as another – for example, 1,234,000 would be stored as 1234 (the mantissa) and 3 (the exponent), for 10^3. Computers actually do this in binary, rather than the base 10 we are used to, but the principle is the same.

But floating-point numbers are only a useful approximation of real numbers; they are inherently inaccurate because of the limited number of digits they can store. For example, a system designed to store 1,234,000 might struggle with 1,234,567, because this would require more digits for the mantissa. Such limitations mean floating-point numbers can cause real-world issues.

"You have to compromise on the accuracy if you want to represent a large range of numbers"

Now, Itamar Cohen at Ariel University and Gil Einziger at Ben-Gurion University, both Israeli institutes, have designed an adapted version of floating-point representation called floating-floating-point that they say can improve accuracy and keep the amount of data required to represent the numbers to a minimum.

Essentially, floating point can assign more bits to the exponent, which increases the range of numbers that can be represented, or more bits to the mantissa, which increases the accuracy of the number. Normally this trade-off is set in stone for a particular system, but floating-floating point allows software to move the allocation dynamically, increasing accuracy when needed, or reducing it in order to ramp up the number range if necessary (arXiv, doi.org/nng4).

"You have to compromise significantly on the accuracy if you want to represent [a] large [range of] numbers, and vice versa," says Cohen. "Floating-floating point tries to overcome this." Similar ideas have been proposed, but Cohen says his and Einziger's solution is one that could be implemented to ramp up or down as software runs, so a better compromise is reached more often.

Kirill Bogdanov at the University of Sheffield, UK, says the idea could have benefits in software where numbers vary a lot during computation – shifting from very large to very small – such as in physics simulations. "If it means they can fit something into memory where it was not possible to do before, it might be worth it."

Crucially, the pair have yet to demonstrate whether their idea would mean a hit to computing performance. "The new format, the floating part, has no support in hardware, hence it's likely to have a huge performance penalty – it might work out to be faster to use a fixed representation for numbers and more memory," says Bogdanov. ▮

There are many ways that we can store numbers

EMILIO EREZA/ALAMY

Events

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IceCube, the Antarctic neutrino detector that has identified high-energy particles from the Milky Way

The columnist
Graham Lawton roots for urban tree planting p28

Aperture
Space telescope offers a cornucopia of celestial treats p30

Letters
We must teach everyone how to face the climate crisis p32

Culture
Transcendent exhibit tasks AI with writing choral music p34

Culture columnist
Emily H. Wilson on an instant classic of climate fiction p36

Comment

Finding the spark

When award-winning author **Will Eaves** couldn't write his next novel, he discovered creativity can be found in looking sideways at a goal

ELAINE KNOX

THERE is a tendency among how-to enthusiasts to talk about creativity as if it had fixed objectives: things you know from the start will turn out to be novels, symphonies or paintings. Writers and musicians who have suffered the uncertainties of creation know that this is an unlikely prospectus. If they have to talk about it at all, they cite "artistic vision" and leave it at that.

I think both these approaches are inadequate. Experience tells me that creativity often lies to one side of a declared aim, and "artistic vision" is a redundant metaphor, because what we are considering has a lot to do with vision itself.

Aspiring writers are tempted by the idea that they can identify a template and knock out a thriller. Positions are adopted: "story" is three acts and a cast of characters. Well, maybe so, but only because centuries of artistic evolution have slowly produced forms like the novel. But novels aren't jelly moulds. And Wolfgang Amadeus Mozart didn't write his music in something called "sonata form". These terms come later, after the job is done. The problem becomes clear when you start work, creatively, because the need to believe in a guaranteed objective gets its hooks into you as soon as you encounter difficulties.

Neuroscientists call this need the Einstellung or set effect. (Einstellung is German for "attitude".) It finds that a general tendency exists to favour known methods in problem-solving at the expense of alternatives, even when we think we are looking for them. It has been studied in chess players, but if you have ever tried a key in a lock and discovered that, though there are other keys to be tried, you prefer to keep jiggling the one that doesn't fit, then you have demonstrated this tendency.

The Einstellung effect is also a good way of describing what can happen when an artistic approach stops producing results. A few years ago, when I finished *Murmur*, a novel about Alan Turing, I knew I wouldn't be working that way – intensively, sequentially – again. Nevertheless, I tried a second historical fiction about ancient Britain and then one about silent cinema. Neither took. Meanwhile, I was playing the piano and composing on the side, and that was ticking along nicely.

The side-long view is important. When Mozart and Ludwig van Beethoven spoke of apprehending their musical compositions visually, they weren't being poetic. They were describing their navigation through complex territory. The world about us offers some parallels. Insects and some birds rely less on an internalised map of the world to locate food than on what they see when they are moving. When a bee flies sideways, generating motion parallax, the location of a flower is revealed as much by that motion as by the flower itself. (We use motion parallax, too: look to one side when you are cycling, and you will see the pavement moving by in a blur, while the houses behind it are sharper.)

Here's Beethoven, in 1822, on writing a new piece: "I begin to elaborate the work in its breadth, its narrowness, its height and its depth... It rises, it grows up, I hear and see the image from every angle... I work at several things at the same time." In other words, it is his mobile consideration of the work – seeing it move, moving around it "from every angle", like a bee – that reveals its nature, not any kind of pre-set appearance.

Perhaps artistic vision is a part of physical seeing, in which our expectations for a work are not as important as the work's rising shape; where motion parallax and peripheral awareness, looking away or sideways, matter more than locked-on focus. The artist's need to discover the properties of a new work is an extension of the brain's need to stabilise new stimuli. Creative projects and artistic vision are a part of our animal response to the world, and this is always dynamic, not fixed. ▮

Will Eaves is an author and musician. His latest books are *The Point of Distraction* and *Invasion of the Polyhedrons*

No planet B

Throwing shade

Urban trees make a huge difference amid rising city temperatures, but we need to think a lot harder about what we are planting and where, says **Graham Lawton**

Graham Lawton is a staff writer at *New Scientist* and author of *Mustn't Grumble: The surprising science of everyday ailments*. You can follow him @grahamlawton

Graham's week

What I'm reading
I'd like to have a look at The Essential Tree Selection Guide: For climate resilience, carbon storage, species diversity and other ecosystem benefits *by Henrik Sjöman and Arit Anderson.*

What I'm watching
Alma's Not Normal *on the BBC.*

What I'm working on
A reporting trip to Germany.

This column appears monthly. Up next week: Annalee Newitz

I RECENTLY moved back to my hometown, York, a small city in the north of England. It is historically rich and culturally vibrant, but lacking in one department: trees. According to the council, its canopy cover was just over 10 per cent in 2022, which is on the low side. The European average is around 15 per cent and London has around 20 per cent.

York has plans to do something about this, in recognition of the fact that urban trees have myriad benefits. These include cooling, carbon sequestration, pollution control and flood mitigation; they stimulate economic activity by making cities more attractive and are good for mental well-being. In a nutshell, trees make cities more liveable and prosperous.

The council is planning to increase York's canopy cover to 13 per cent by 2050. That means planting around 4000 trees over the next few years, a process that has begun with the creation of two "micro woods" not far from the city centre. York is hardly a global city, but it is part of a global trend. "Today, we are in a very positive place when it comes to talking about urban trees," says Henrik Sjöman at Gothenburg Botanical Gardens in Sweden. "Cities are almost competing with each other over their plans for planting trees."

But, as I discovered when I attended the recent Greener Cities symposium, planting thousands of trees doesn't guarantee success. It is critically important what you plant and where, and also to look after what you already have.

One of the main benefits of urban trees is that they keep cities and inhabitants cool by providing shade and transpiration – the process by which they absorb water from the ground and vent it into the atmosphere. This cooling effect will only become more important as the climate warms. Stephan Pauleit at the Technical University of Munich in Germany told the symposium that increasing canopy cover in a big city like Manchester in the UK – say from 20 to 30 per cent – will keep urban temperatures roughly where they are today, even as the world gets hotter overall.

But at the same time, climate change is a threat to urban trees. Between 2016 and 2022, Pauleit and his colleagues monitored 1.34 million trees in five German cities. Each year, between 1 and 2 per cent of them died – which is to be expected, as trees get old and expire. But there was a major spike in mortality in the heat wave summer of 2019. At the overall rate of attrition they found, half of urban trees will have died by 2050.

> **"The loss of mature trees is a major problem because they supply way more cooling than younger trees"**

The loss of mature trees is a major problem. According to Pauleit, an 80-year-old lime tree supplies an order of magnitude more cooling and sequestration of carbon than a 20-year-old one. "It's really important to protect old trees," he said.

There are other threats. Two invasive species of longhorn beetle, Asian and citrus, recently arrived in North America and Europe. Both lay their eggs under tree bark and their larvae can eat a tree to death. A recent study by Sjöman found that a serious outbreak of either of these pests could kill a quarter of the trees in 10 Nordic cities; in a simultaneous infestation of both species, urban tree mortality could exceed 90 per cent. "The question is not if we have an outbreak of these beetles, but when," he told the symposium.

Both of these problems are exacerbated by the limited diversity of urban trees. In the London borough of Camden, for example, just five species account for three-quarters of trees, according to Sjöman. There is a similar lack of diversity in Beijing, Pittsburgh in Pennsylvania, and Barcelona, and nearly half of trees in Finland's capital Helsinki are a single species, the common lime.

Such trees are tried and tested urban choices, but as the climate warms, they may no longer be fit for purpose. So cities need to plant with the future in mind. But as to what to grow instead, there is a lack of information and an unwillingness to branch out. "It's not surprising," said Sjöman. "You don't want to be the famous landscape architect... designing the square where everything died."

That is why Sjöman and his team have been experimenting in what he calls his "torture chamber" at the University of Gothenburg. There, they subject non-traditional species to extreme conditions, such as drought and flooding, to see which tolerate them the best. He has already identified three candidates for future urban afforestation – the chestnut-leaved oak from Azerbaijan, silver lime from Romania and Lebanese wild apple. "They love heat and drought. These are trees we could, should and have to see more of in urban environments."

Back in York, I got on my bike and went to one of the micro woods. There are about 50 saplings, mostly (as far as I could tell) from the standard repertoire. They will take decades to mature. I am rooting for them, but I fear the world they are growing up in won't be kind to them. ▮

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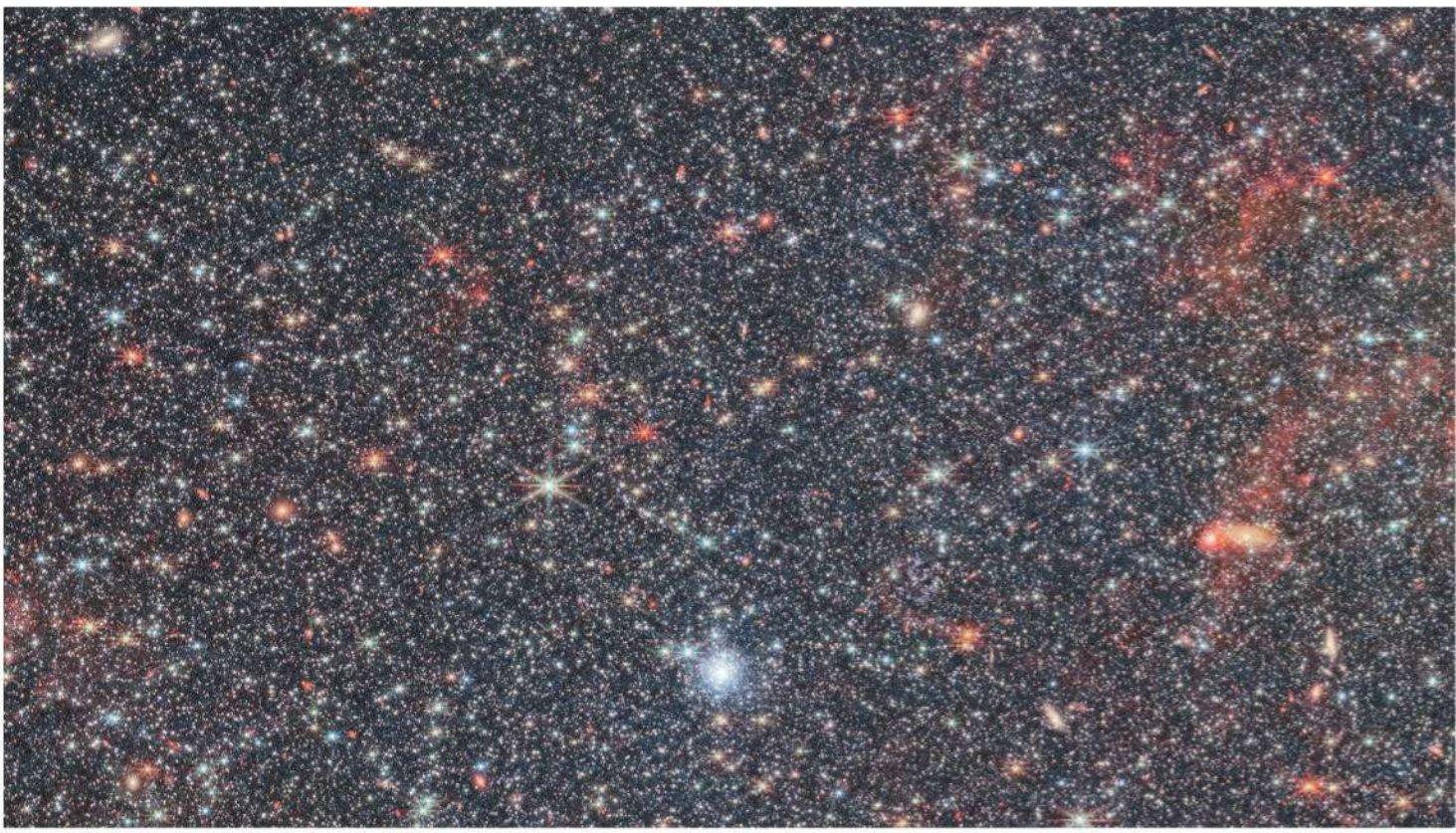

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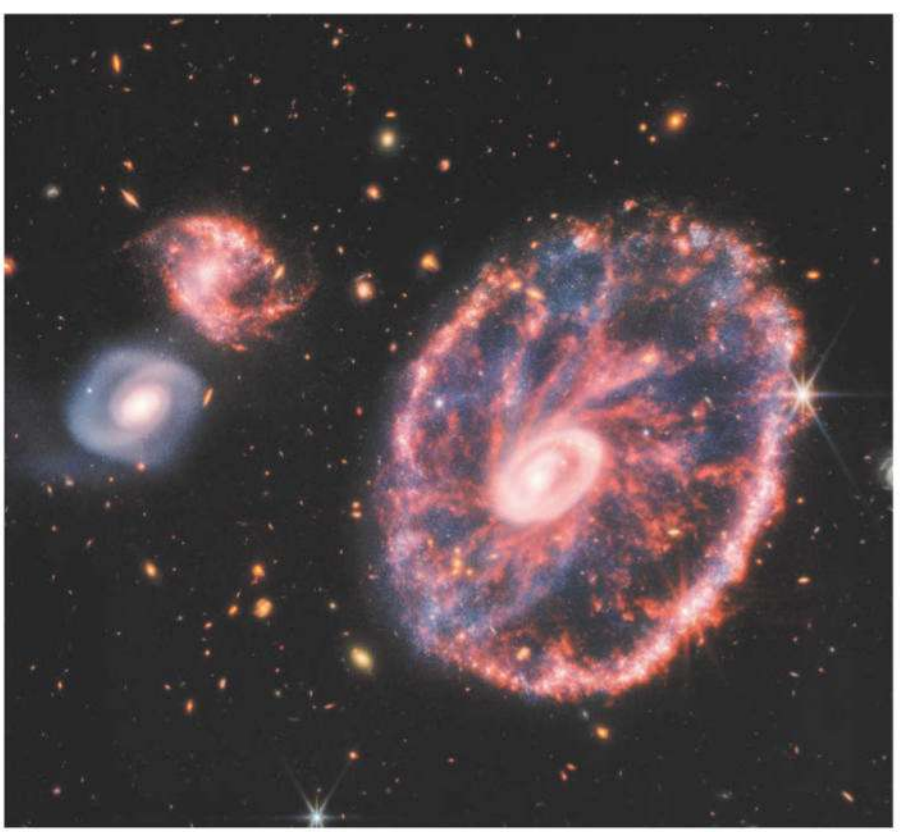

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A sea of stars

Michael O'Mara Books

IN ITS short existence, the James Webb Space Telescope (JWST) has cast its eye over a cornucopia of celestial treats and transformed our understanding of the universe.

Space scientist Maggie Aderin-Pocock, presenter of *The Sky At Night*, highlights some of its best images in her new book *Webb's Universe: The space telescope images that reveal our cosmic history,* detailing the science behind each striking view and giving an insider's take on how JWST's technology was developed.

"The detail the telescope can get, the wonderful resolution it gets with its six-and-a-half-metre mirror, results in some glorious images," says Aderin-Pocock, who worked on the telescope.

The field of stars at top is part of Barnard's galaxy. This contains Barnard's star, one of Earth's closest neighbours, which was recently found to have its own planet. Even in crowded fields of stars, JWST can focus on small patches of the sky using a microshutter array, tiny flaps that can block out unwanted light, which would aid study of the star.

There are still many mysteries about star birth, but the answers lie in nebulae, like the Carina nebula (far left, bottom) – vast tracts of gas and dust that are stellar nurseries. "Looking with optical telescopes, not all visible light can pass through this dust and gas," says Aderin-Pocock. "When we look at it with an infrared telescope [like JWST], suddenly we see... details we haven't seen before."

The Cartwheel galaxy (near left, bottom) is the result of a smash up of two smaller galaxies. It may help us understand the fate of our galaxy, the Milky Way, in billions of years, when it will collide with the Andromeda galaxy.

Alex Wilkins

Editor's pick

We must teach everyone how to face climate crisis

12 October, p 8

From Denis Watkins, Truro, Cornwall, UK

"We are on the brink of an irreversible climate disaster," write William Ripple and colleagues at Oregon State University in their report on the state of the planet. As there are no indications of effective global cooperation, or political leadership, to tackle this emergency, we need parallel arrangements. I mean education and training to prepare the population emotionally to cope with what is so devastating and so rapidly approaching.

AIs can still rule even if they can't add up

5 October, p 14

From Wade Schuette, Columbia, Missouri, US

You note that "AIs get worse on simple questions as they get bigger" and that they have trouble adding two large numbers. Remember that Henry Ford built a great automobile company not by becoming an expert, but by drawing on experts.

If AI can solve how to iteratively create a team of experts to solve a problem it faces, that is all it needs to do to address any shortcomings. It can delegate adding large numbers to a classical computer. It can use databases and classical "rules-based expert systems" to work through lists. It can write Python computer code, or hire someone who can. It can assemble a team of diverse advisers who can tell it when it is going astray. It can ask 20 people and compare their answers.

Stepping outside your niche really is vital

21 September, p 22

From Nick Hunn, London, UK

I enjoyed Chanda Prescod-Weinstein's look at stepping outside her scientific comfort zone. It reminded me of a line in Kurt Vonnegut's novel *Player Piano:* "Show me a specialist, and I'll show you a man who's so scared he's dug a hole for himself to hide in." As a physicist who has spent my working life in industry, I see the same issues that Chanda observed within academia, which is an overwhelming aspiration to specialise, rather than reap the benefits of a broader perspective.

This leads to multiple, parallel reinvention, where industries fail to share knowledge. I increasingly see the same issue in graduates who have gained little breadth of knowledge or application, but have been indoctrinated into the cult of specialism. It feels more important than ever that we try to connect thinking across different industries and disciplines.

Edible oil from waste could take environmental crown

5 October, p 15

From Guy Cox, Sydney, Australia

While camellia oil might use less land than many other oil crops, can I point out that rice bran oil requires zero land, since it is made from what is often considered a waste product – and the world isn't going to stop eating rice. This oil is popular in many Asian countries, and in Australia, though seems to be little known in the UK and US. It has a healthy fatty acid balance, nice taste and a high smoke point. Surely it is the greenest oil?

True democracy? Those in power may well resist

5 October, p 32

From Robert Bull, Bath, Somerset, UK

"Reimagining democracy" starts by noting that current "democracies" favour the rich. It ends by reporting that an attempt to roll out a more truly democratic model across the UK has been vetoed by government because "there is no money". Turkeys, of course, don't vote for Christmas.

South and north, the poles are melting away

12 October, p 15

From David Myers, Commugny, Switzerland

It isn't only in the Antarctic that temperatures have gone crazy. At the end of August, my wife and I visited Svalbard, well inside the Arctic circle, where temperatures would normally be 4°C to 11°C (39°F to 52°F) in the summer, and were told that it had been up to 20°C (68°F). We travelled to the far north, where we found valleys whose glaciers had entirely melted. The walruses seemed very happy to lie in the sun, though.

We then crossed the Arctic Ocean and spent some time visiting the fjords in eastern Greenland, where I was surprised that a lot of ground is entirely snow-free to a significant altitude.

I can't praise this nature writer enough

5 October, p 28

From Gina Langford, Canterbury, Kent, UK

I liked James McConnachie's review of *England: A natural history* by John Lewis-Stempel, and feel he gave the author a fair hearing, but would add more praise.

I have read several of Lewis-Stempel's offerings. He may do his work alone, as you point out, but he has the power to make me understand crucial aspects of nature, for example, the importance of fertility in the soil in his 2016 book *The Running Hare: The secret life of farmland*.

You are worth more than the whole of mathematics

5 October, p 36

From Gerard Buzolic, Coolum Beach, Queensland, Australia

In her article on why we avoid effort, Amanda Ruggeri mentions the so-called IKEA effect: that we prefer a less well-made bookshelf that we have assembled ourselves over something ready-made and perfect. "Our effort," she says, "adds value."

I would say we underestimate the importance of our ability to give value to people and things. Students think mathematics is bigger than they are because they struggle to understand it, but, compared with mathematics, they are worth far more. We give value to people and things by noticing them, enjoying them and then working for them. As it says in *The Little Prince* by Antoine de Saint-Exupéry: "It is the time you have wasted for your rose that makes your rose so important."

Efficient driving and the long arm of the law

Letters, 28 September

From Dave Appleby, Eastbourne, East Sussex, UK

Those readers discussing how to drive more efficiently, take note. The only time I have been stopped by the police and breathalysed – the result was negative – was after they observed me practising smoother driving and less braking to conserve fuel. You might call it "reducing emissions". They called it "erratic driving". ▮

For the record

▮ **Kristian Nielsen at Copenhagen Business School in Denmark was the researcher investigating perception of carbon footprints (28 September, p 19).**

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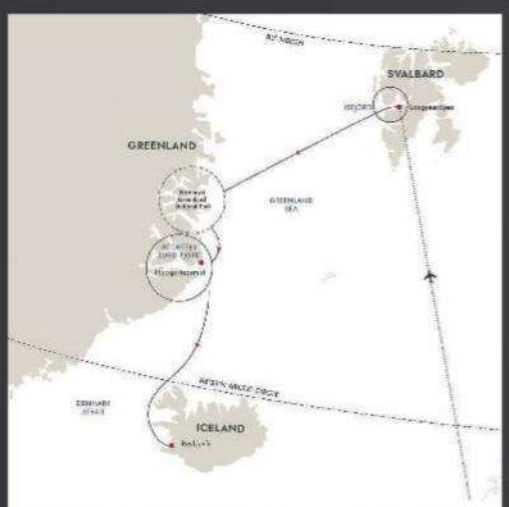

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Can AI rock your soul?

A moving exhibition explores what happens if AI is trained to write choral music by feeding it a specially created vocal dataset, finds **Bethan Ackerley**

Exhibition

The Call

Holly Herndon and Mat Dryhurst

Serpentine North, London

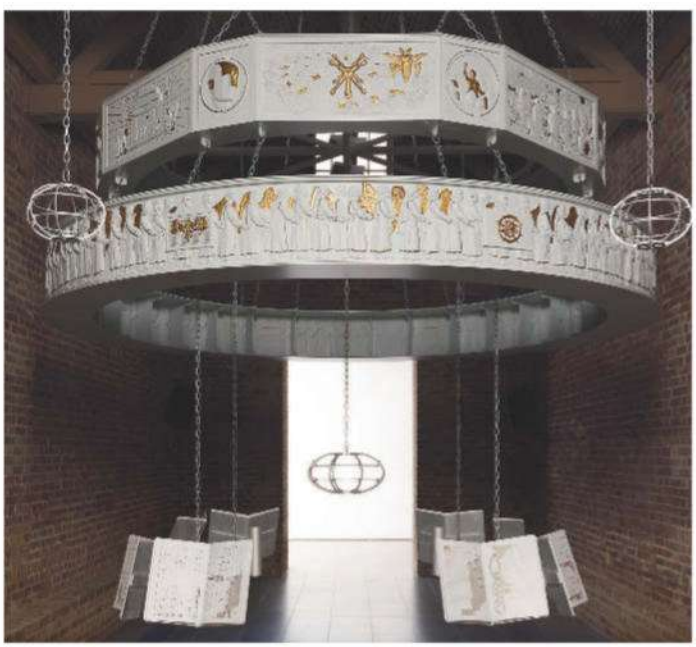
Closes 2 February 2025

STEP into London's Serpentine North gallery and the first thing you see is an organ. But it is far from a conventional instrument with gleaming flues and reeds. This organ is made up of fans used to cool graphics processing units. Each fan whirs at a pitch that depends on its oscillation, and the sounds combine in an otherworldly hymn generated by artificial intelligence.

This communion of AI and the divine drives The Call, the first solo exhibition in the UK by Berlin-based artist duo Holly Herndon and Mat Dryhurst. They worked with 15 choirs across the UK to create a vocal dataset, which they used to train AI to produce choral music. Their work is guided by the mantra that all media is training data, but, as Dryhurst asks, "why not make that performative and deliberate?"

The GPU-fan organ is called The Hearth by the artists, to signal a place that brings people together. After spending time there, you move on to the South Powder Room. Here, you listen to field recordings of choirs singing exercises from a songbook devised by Herndon and Dryhurst to contain all the distinct units of sound, or phonemes, in the English language.

Inspired by the Sacred Harp tradition, where musicians sing towards each other without an audience, the choirs were arranged in two concentric circles and their music was recorded in 360-degree audio. In the South Powder Room, a chandelier evokes the intricate rig of microphones used to capture the audio, and is inscribed with a frieze of cameos depicting recording sessions.



LEON CHEW, THE CALL, HOLLY HERNDON AND MAT DRYHURST WITH SUB, SERPENTINE, 2024

A chandelier evokes the rig of microphones used to capture the recordings

These strict data collection protocols are about more than simple logistics: for the artists, they are rituals designed to reveal AI's potential as a "coordination technology" allowing individuals to make art and culture collectively, just as singing did in early human societies. "We're trying to create a historical through-line to make the technology feel less alien, feel more like it came from us," says Herndon.

At the fringes of the gallery, visitors can hear the results as they listen to compositions by Herndon and Dryhurst, made using models trained on the choral dataset. The pieces are tranquil and strange, gliding over the ear. Left hanging, however, is the question of authorship and remuneration. Who owns this music: Herndon and Dryhurst, the choirs, the gallery?

"The voice is a great way to explore how humans make something bigger than themselves"

This sticky aspect of The Call is a natural evolution of the issues raised by the artists' previous work. Take Holly+, an AI clone of Herndon's voice the artists released in 2021. It can be licensed by anyone to make art, after approval by a decentralised organisation of custodians who protect its value.

But it is one thing to fashion a digital likeness of your voice and release it into the world for all to use, and quite another to steward the data of a community and decide how that ought to be used.

The voice is a great way to probe how humans collaborate to make something bigger than themselves, says Herndon: "You have an individual voice that you perform with agency, but you learned that voice through mimicking your parents and learning the language around you." That push-pull, she adds, is an apt analogy for AI.

Engaging with AI means moving past views of unalloyed good or mindless tech killing the planet. There is a popular misconception of two opposing sides: the AI companies and the artists who hate them, says Dryhurst. "Nobody's telling that story in a way that's sympathetic to the complexities."

The small AI models behind The Call aren't the energy-guzzling behemoths of major AI firms, and the future of the dataset after the exhibition rests with the choristers, who are in negotiations with Herndon and Dryhurst and the Serpentine Galleries. The aim is to create a data trust that offers control and compensation to the artists whose work is used to train AI.

If I had one criticism of The Call, it would be that this legal and ethical aspect deserves a larger part of the exhibition. But it is hard to keep that in mind as you enter The Oratory, the final chamber of the exhibition. Here, each visitor is invited to sing into a microphone and hear a polyphonic AI harmonise in real time. I found it a transcendent experience, where AI's limitations and imperfections are present without intruding.

There are plenty of unknowns about governance, ethics and ownership to fathom. But if you question whether AI can stir the soul, then a moment spent singing through The Call's celestial voice should put scepticism to bed. ▮

Being Marie Curie

A rich biography shows how the pioneer of radioactivity used her lab to redefine the role of women in science, says **Chen Ly**

Book

The Elements of Marie Curie
Dava Sobel
Fourth Estate, UK; Grove Atlantic, US

ON 7 November 1867, Marya Salomea Sklodowska was born in Warsaw, then part of the Russian Empire. She was the youngest of five children, and became known as "Manya" by her family.

She was a voraciously curious child who learned to read at the age of 4 and developed a fascination with science, thanks in large part to her father, a teacher of physics and mathematics. Even so, no one could have predicted that this young girl would grow up to become Marie Curie, one of the most celebrated scientists of the 20th century.

In *The Elements of Marie Curie: How the glow of radium lit a path for women in science*, writer Dava Sobel traces Curie's extraordinary path. Curie's pioneering research on radioactivity – a term she coined – placed her at the cutting edge of science. Yet beyond her academic achievements, Sobel reveals a portrait of quiet determination, resilience and compassion, traits formed by a lifetime of personal hardship and profound loss.

Drawing on Curie's personal letters, as well as the accounts of friends, family and colleagues, Sobel crafts a deep and intimate glimpse of the woman behind the science. She highlights not only Curie's professional triumphs, but also the human story that defined her life, made richer by the relationships she cultivated with those around her.

The book's structure is distinctive, with each chapter named after a key figure in Curie's life – individuals who shaped her life's work or were shaped by their connection to her. While Curie's relationships with husband Pierre and her Nobel prizewinning daughter Irène are explored, Sobel also reveals the lesser-known women in her orbit.

These include the women she trained, her "laboratory daughters" as Sobel calls them. We meet Irén Götz, the first female professor at a Hungarian university, and Ellen Gleditsch, who determined the half-life of radium and went on to become the second woman to join the Norwegian Academy of Sciences and Letters.

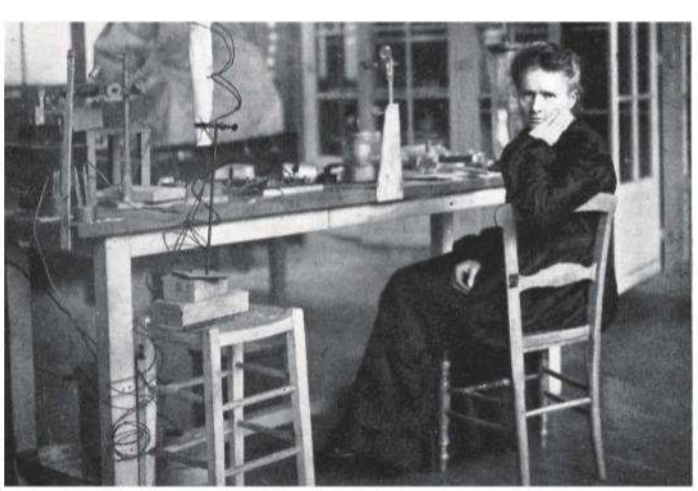
Curie's dedication to science extended far beyond the lab. During the first world war, she trained women to operate mobile X-ray units, providing critical medical care at the front line. After the war, as a leading member of the League of Nations' International Committee on Intellectual Cooperation, she promoted collaboration among scientists. Both of these activities reflected her commitment to applying science for the greater good, showing that she wasn't just a brilliant researcher but could prove a compassionate leader.

Sobel also sensitively explores the emotional toll of Curie's personal life. Her mother and eldest sister died before she was 10. She also faced the untimely death of the supportive Pierre, who had campaigned to ensure she shared his half of the 1903 Nobel prize. Curie had to raise their two young daughters while she continued her research.

In later life, she faced persistent health issues, most likely caused by her exposure to radiation, yet her determination never faltered. This perseverance saw her win Nobel prizes in two scientific fields, physics and chemistry – the only person to have achieved this so far.

***The Elements of Marie Curie* is much more than a biography. It is a tribute to a woman who redefined what was possible for women in science, inspiring generations to follow her. Sobel's elegant prose and thoughtful use of personal and historical accounts bring Curie to life, offering a nuanced portrait of a woman whose contributions to science were matched by quiet strength, humility and commitment to humanity. This is an essential read, capturing both her genius and her legacy.**

Chen Ly is a writer based in London



Marie Curie pictured at work in her laboratory in Paris, in 1912

UNIVERSAL HISTORY ARCHIVE/GETTY IMAGES

New Scientist *recommends*

Tom Leslie
Junior subeditor
London

Stories about science can be a tough sell to friends and family, particularly if they lack the human-centred narratives of a political scandal or court case. Luckily that isn't so a documentary that had

its UK launch recently. **Hunt for the Oldest DNA** is a tight, well-produced work that focuses on a competitive, adventurous, rule-breaker called Eske Willerslev (pictured), who bet his career on finding prehistoric DNA in Arctic permafrost. There are some flaws – the harm Willerslev's ambition causes to others deserved more attention – but the overall result is a thought-provoking character study.

Anyone who has run into me lately will also have had their ears talked off about Vernor Vinge's sci-fi novel **A Fire Upon the Deep**. I may be 30 years late to the party, but it remains an excellent space opera with a unique solution for keeping humans relevant in the universe after the AI singularity. Besides, who wouldn't want a best friend in the shape of a pack of alien puppies?

HANDFUL OF FILMS INC

The sci-fi column

Hot as hell A man and a young girl drive across a scorched Australian outback, like a scene from a *Mad Max* movie. Except that this is *Juice*, an extraordinary new novel by Tim Winton, and nothing is what it first seems, says **Emily H. Wilson**

Emily H. Wilson is a former editor of *New Scientist* and the author of the *Sumerians* trilogy, set in ancient Mesopotamia. The second book in the series, *Gilgamesh*, is out now. You can find her at emilyhwilson.com, or follow her on X @emilyhwilson and Instagram @emilyhwilson1

ANDREW MERRY/GETTY IMAGES

In the post-collapse outback of *Juice*, people live partly underground

Book
Juice
Tim Winton
Picador

Emily also recommends...

Book
The Animals in That Country
Laura Jean McKay
Scribe
Another outback novel, although very different. This is the story of a strange pandemic that allows those infected to understand the language of animals. Poetic, weird and wonderful.

THE latest novel by Tim Winton (twice shortlisted for the Booker prize) is *Juice*, and it begins in a deceptively familiar, even clichéd fashion. A man and a young girl in a futuristic, pimped-up vehicle are crossing a post-apocalyptic Australian outback. Even in the real world, the outback holds many dangers for the unprepared. Winton's fictional, far-future outback is so hot and ruined that it is barely survivable even for the extremely experienced and well-prepared man at the wheel. And the girl he is travelling with seems too traumatised to help.

The pair finally stumble on an old mining complex. They hope to find shelter and respite there, but instead end up prisoners of a stranger with a crossbow. The stranger has the white lesions on his face that everyone in this seared world does, but he also has scars that hint at a history of a certain kind of violence. So far, the story could be from *Mad Max*, or *The Girl With All the Gifts*, or a host of other post-collapse tales.

But then the true architecture of this extraordinary book reveals itself. To survive the bowman, our narrator decides to sing for his supper. He hopes, we presume, to convince the bowman that he and the girl are no threat and, indeed, that they might help the stranger survive and thrive. Our hero also, we come to believe, senses a shared history with the bowman, one that may even win the captured pair sympathy.

> **"*Juice* is a heavyweight literary novel that sits squarely in the growing canon of 'climate fiction'"**

And so, from inside a makeshift prison cell, deep underground, our hero relates the story of his life up to that moment. He begins with his early years as a hard-working, innocent, plains-dwelling homesteader. He and his staunch and capable mother live above ground for nine months of the year, and below for the most brutal three months of summer. They must collect water and grow things in the most terrifyingly dry landscape, but they must also guard against possible drowning if huge storms arrive suddenly.

Our hero's hard but predictable life is disrupted when a secretive organisation recruits him to become a warrior tracking down climate-change criminals. Because when things collapsed, not everyone ended up in vulnerable homesteads on the open plains...

In telling his story, our narrator also reveals the whole history of the world in the post-collapse centuries, from the fossil fuel corporations ushering in doom to the long terrors afterwards. I won't say more about the plot, except that it is gripping and likely to keep you up at night.

Someone asked me if the book was depressing, and I said no. After all, it is exciting, a great yarn. But it may make you look afresh at all around you. At the conduct of the corporations and the people who sit astride them; at the pitifully slow response to climate change from national governments. *Juice* asks big questions about culpability and what might be suitable retribution for the descendants of those who are, right now, knowingly taking us closer to climate catastrophe. And, of course, unless you are already a climate saint, the list includes you and me.

So, yes, this isn't a depressing book per se, but you may find it to be a terrifying one. I very much hope this history of our future never materialises.

That aside, it is a barnstorming, coruscating work of fiction, a heavyweight literary novel that sits squarely in the growing canon of "climate fiction" and it feels to me to be an instant classic of that genre. I strongly recommend it. ▮

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Black holes, inside and out

Physicists say they have resolved an infamous black hole paradox – although that has only deepened the mystery of what really goes on within them, finds **Leah Crane**

IN MARCH 1974, Stephen Hawking published the paper that made his name. It contained the revelation that black holes – gravitational giants from which nothing, not even light, can escape – don't grow and grow until the end of time, but instead slowly shrink as they release particles in a phenomenon now called Hawking radiation.

The implications were mystifying. Hawking's calculations showed that the radiation should be random, offering no way to predict what types of particles will emerge. The problem was that anything that falls into a black hole contains information – what sorts of particles it is made of, their configurations, their quantum states – and if what comes back out is random, that information is lost forever as soon as the object is sucked in. But physics operates on the idea that, if we know all the information about a system, we can reconstruct its past and predict its future.

Can black holes really do the impossible, destroying anything and everything they pull in? That prospect is called the black hole information paradox. It has occupied physicists for decades, not only because it highlights the profound disconnect between general relativity, Albert Einstein's theory of gravity, and quantum theory – but also because it offers the hope of a reconciliation.

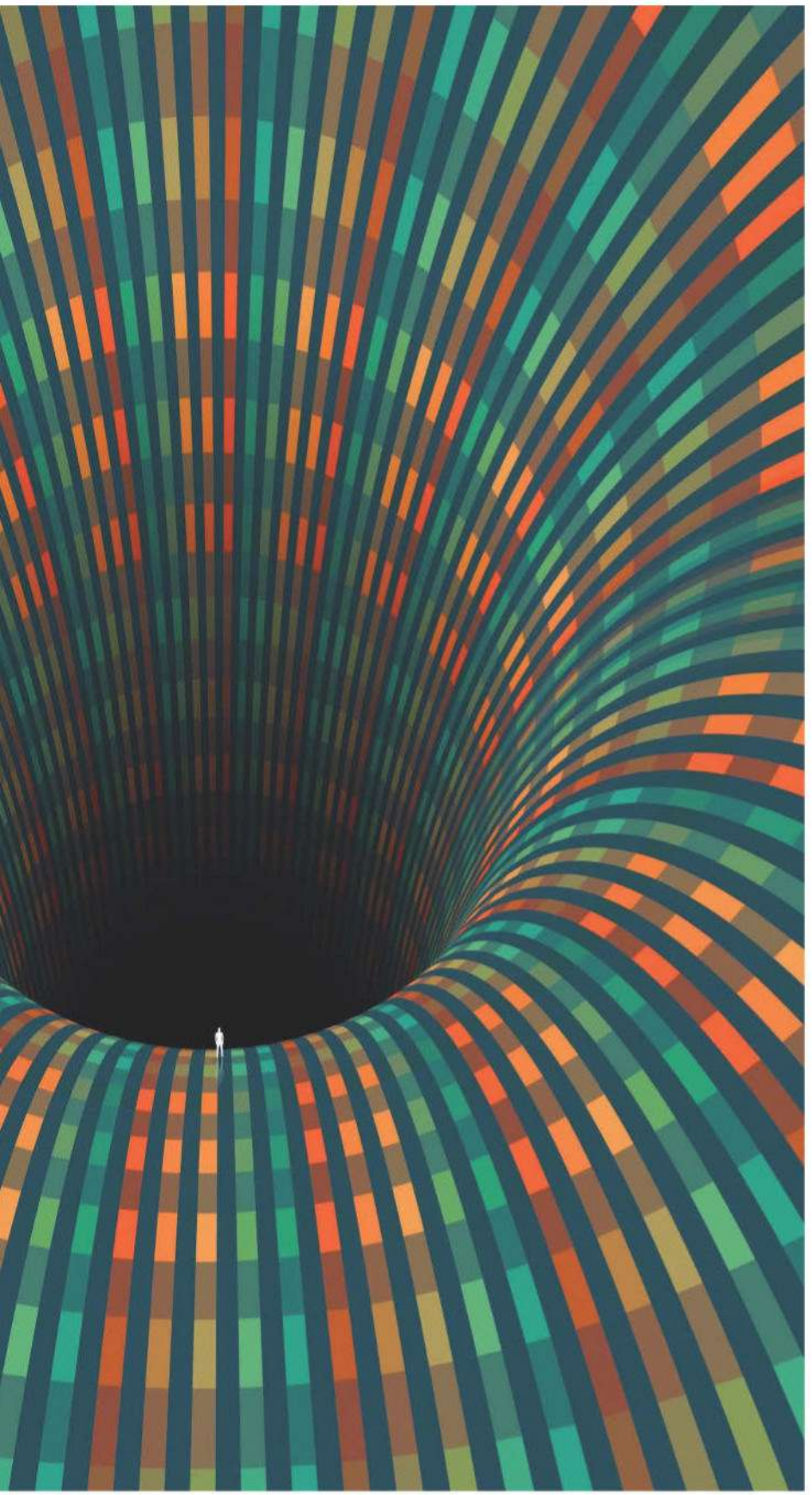
Now, 50 years after its inception, the paradox is all but solved. And yet physicists aren't celebrating as you might expect because their solution hasn't resulted in a long-sought quantum theory of gravity. In many ways, it has only deepened the mystery of what happens inside black holes – and what that tells us about how the universe works at its most fundamental level.

The black hole information paradox is a conflict between two apparently incontrovertible facts. The first stems from quantum mechanics, which describes the workings of atoms and subatomic particles. It says that all processes are what physicists call unitary, meaning that if you have all the available information about the system now, you should be able to calculate all of its past properties. "If you have a glass of water and you drop some ink in it, after a while, all the water looks uniform," says Juan Maldacena at the Institute for Advanced Study in Princeton, New Jersey. "But if you kept track of all the molecules in the system, you could, in principle, figure out where you dropped the ink into the water, so that information is retained."

"That's one of the big tenets of quantum physics, that you should be able to rewind the movie," says Xavier Calmet at the University of Sussex in the UK. "If one object violates that principle, then the theory breaks down and you have to throw away the theory."

Binning quantum mechanics isn't an option, however, because it has stood up to every test physicists have thrown at it. Nor can we throw out thermodynamics, which deals

MICHAEL STREVENS



with work and energy and follows a similar rule about unitarity. If black holes destroyed information, as Hawking calculated, two of the most thoroughly tested areas of physics would have to be incorrect. But for decades, physicists couldn't prove his calculations wrong.

Something had to give, which brings us to the second apparently incontrovertible fact: that semiclassical physics, a well-established combination of general relativity and quantum mechanics in which the two theories are treated roughly separately, describes what goes on at the edge of a black hole.

Hawking did his original calculations based on semiclassical assumptions, and it took a while to find fault. Slowly but surely, though, his workings began to crack. In 2004, Hawking himself realised that the amount of information left behind in space-time when a black hole completely evaporates should be equal to the amount that was present when it formed, regardless of how much had fallen into the black hole in the meantime. "If you jump into a black hole, your mass energy will be returned to our universe, but in a mangled form, which contains information about what you were like, but in an unrecognisable state," Hawking said in a 2004 press conference. The information was coming out, he conceded, suggesting that semiclassical physics alone isn't enough to make sense of black holes. But his research said nothing about how.

Everything is quantum

A further path out of the paradox appeared on the horizon as researchers began to make inroads into what a theory of quantum gravity might look like, and physicists began to consider how quantum effects might modify Hawking radiation. "To solve the paradox, you have to accept that everything is quantum, not just tiny particles – [but also] planets, black holes, the universe," says Calmet. "If you think of the black hole as classical, you are lost."

One way in which a quantum black hole is different from a classical one is in how it affects the surrounding space-time. Classical black hole space-time is perfectly spherical because black holes themselves should be perfectly spherical, thanks to their extremely powerful gravity. But quantum fluctuations mean that a quantum black hole should ›

warp space-time in a very slightly uneven way – and that asymmetry can store information, says Calmet.

In 2023, he and his colleagues calculated that this slight asymmetry in space-time should affect the Hawking radiation, so that it isn't completely random. "Even when the black hole evaporates completely, the information remains in the radiation and in space-time," says Calmet. "They're very tiny effects, but they're enough." The information that comes out would be thinly spread across a huge volume of space-time, which is why it was so hard to mathematically find.

Raphael Bousso and Geoff Penington at the University of California, Berkeley, made a similar finding in late 2023, although with a slightly different mechanism. Hawking radiation is the result of pairs of particles being produced at the very edge of a black hole, one of which falls in while the other radiates outwards. These pairs are connected through quantum entanglement, a phenomenon in which the measured properties of each particle depend on those of the other.

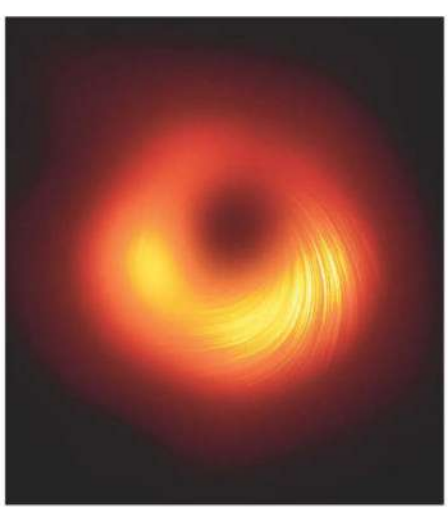
If we could measure the particles that escape, that might give us some information about the properties of their doomed partners. This could create "entanglement islands" of information about the inside of a black hole, stretching out from its edge. Researchers thought that these islands – perhaps more accurately described as peninsulas – would protrude from a black hole by a length smaller than anything we could measure, making them effectively non-existent. But Bousso and Penington found that they could stick out by as much as an atom's width, again warping space-time and allowing information out.

That isn't very far, of course, but in principle it is measurable. And what matters for the black hole paradox is that the information is theoretically accessible, not that accessing it would be remotely practical.

In any case, at this point, most physicists agree that information is preserved, not destroyed. Hence the claims that the black hole paradox has finally been resolved. "This has been a big change in the last four years or so," says Calmet, though not everyone believes that it amounts to a conclusive resolution.

"There's been progress for sure, but I definitely wouldn't say that all the i's are dotted and all the t's are crossed," says Neil Lambert at King's College London. "The evidence is now very overwhelming that the information is preserved, but I'm not convinced that we know how to do the calculations to recover the information."

"The resolution hasn't led to a new formulation of quantum gravity"



EHT COLLABORATION

The supermassive black hole in galaxy M87, imaged by the Event Horizon Telescope

The biggest issue is that the resolution hasn't led to a new formulation of quantum gravity – something that goes beyond the semiclassical physics Hawking used in his original calculations. "We couldn't understand it with known physics, so it seemed like it could point the way to what fundamental physics really underlies everything," says Don Marolf at the University of California, Santa Barbara. "But I think it's been the opposite." Allowing information to escape a black hole doesn't require string theory or any other particular formulation of quantum gravity. That leaves open the question of which, if any, of the many formulations is correct.

Part of the problem is that even if we figure out exactly how quantum physics works at the edge of a black hole – the general shape of which we seem to understand, although the details are still a bit fuzzy – what happens further in remains a mystery.

"The calculation part appears to be done, but there does remain the interesting question of what does it mean for physics inside the black hole?" says Marolf. "If you fall into an evaporating black hole, what does that feel like? Could you live in there if you made it in? Can you just go about your normal life or is the physics so weird that you would be immediately destroyed? Those are the things that we argue about."

For a while, physicists skirted the issue by positing what they called a firewall – the idea that physics on the inside of a black hole was so unlike that in the rest of the universe that it was impossible to access. Instead, there would be a moat of extraordinarily high-energy particles right at the edge that would incinerate anything that got too close. Some even argued that space-time would cease to exist beyond the firewall, so black holes would have no interior at all.

That idea has fallen from grace in recent years, replaced by insights gleaned from arcane calculations about the relationship between a black hole's interior and exterior. Many of these hypotheticals deal with the

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The consensus now is that black holes don't destroy information

entropy, or disorder, present inside a black hole. This is related to how many quantum states exist there, similar to how the information content of a book is related to how many letters fill its pages.

In classical physics, a black hole can contain an infinite number of quantum states, but recent calculations indicate that there are fewer than expected, because many configurations of states that appear distinct are actually equivalent. A black hole that might seem from the outside to have a volume of 20,000 cubic kilometres, say, could actually be only one-tenth that big when observed from the inside. "It seems like, indeed, physics is very strange inside a black hole, that things you would have thought are apples and oranges are actually the same, but we don't quite [fully] know what that means physically yet," says Marolf. It does seem to imply, however, that an astronaut outside a black hole would measure very different properties from what an astronaut inside the void would see.

It isn't clear how to figure out the details of those differences theoretically, and directly observing the interior of a black hole is out of the question, so physicists are at an impasse for now. "It is sort of sad in that sense, but until we build a black hole big enough to jump in, I think it's hard to tell," says Marolf.

In the meantime, the best we can do is to work with experimental systems that have shown promise at mimicking some black hole properties. Most of these are made of perfect fluids that flow with no friction or viscosity. These strange substances, which include Bose-Einstein condensates and superfluid helium, move similarly to fields in space-time, particularly gravity. As a result, they can be used to create peculiar flows that behave in some ways like black holes. How these flows interact with sound is similar to how black holes interact with light, allowing researchers to use them as artificial black holes.

Black hole analogues

Such models have even displayed behaviours similar to Hawking radiation, but many physicists are sceptical that they can capture the full complexity of black hole behaviour. "People talk about analogue black holes a lot, but they just aren't the same. They don't evaporate in the same way," says Marolf.

Inside a black hole, the roles of space and time are radically recast, which is difficult or even impossible to reproduce in a laboratory. "These analogues, there's an analogy, but it's not really getting at the big issue, which is that space and time are changing roles inside that black hole," says Lambert. "When you're outside a black hole, it's a point in space and it stays that way. But when you fall into a black hole, it ceases to be a point in space for all time, it becomes a point in time for all space. It's an object everywhere in your future." This inescapability, this altering of space and time themselves, is what is challenging to duplicate or even explain.

Another potential route to analogue black holes comes through quantum computing. So far, it has proven impossible to simulate a black hole in detail on any existing computer – the interactions between gravity and quantum mechanics at the edge of these objects are simply too complicated. But quantum computers are better suited than conventional machines to deal with that sort of complexity. They run on quantum effects, so it is far easier for them to simulate the quantum world.

The question with quantum computing, then, isn't whether it can simulate the quantum effects in a black hole, but whether it can square those effects with gravity. "It might be that with sufficiently big quantum computers we could realise these analogue systems that display some version of gravity," says Maldacena. Tech companies are aiming to build quantum computers in the size range that he says would be necessary within the next decade or so, so that may be a path forward.

Not all black hole researchers are quite as hopeful, though. "On the one hand, I don't personally have, nor do I know of, anything that seems like a useful idea for sorting [this mystery] out. On the other hand, it took us almost 50 years to figure out that information comes out at all," says Marolf. "Maybe future scientists will have new, better ideas."

If they do, it could pave the way towards a better grasp of not just black holes themselves, but of all the physics underlying them too. That physics is crucial for understanding the origins of space-time itself.

"Black holes are wild – it's crazy what they do – and that might let us get a grip on the role of information in both gravity and quantum mechanics," says Lambert. "It promises to be quite revolutionary. It's an area where, if we ever understood it, we could be in for quite some revelations." ▮

Leah Crane is a features editor at *New Scientist*

The twilight zone

A new understanding of the weird moments between wakefulness and slumber could enhance creativity and even lead to fresh treatments for some sleep conditions, says **Graham Lawton**

WHEN he was in need of inspiration, the inventor Thomas Edison used to take a nap in a chair while holding a metal ball in each hand. The moment he dropped off, the balls would drop too and crash to the floor, jolting him awake. Edison claimed that this allowed him to capture creative ideas that had fleetingly bubbled up into his semi-consciousness as he fell asleep.

The state Edison was chasing is known as the sleep-onset period (SOP), a little-studied phase of the sleep-wake cycle. Once seen as merely a brief interlude between wakefulness and slumber, it is now being recognised as a distinct and important stage in its own right. Not only is it involved in orchestrating the shutdown of consciousness, but it may also play a vital role in many of the functions of sleep, including memory-processing and, of course, creativity.

For some people, however, it can be disordered; insomnia and narcolepsy could be the result of it going awry. A better understanding of the SOP could lead to new treatments for these sleep conditions, while also helping anyone who wants to be more alert or creative – so "pretty much everybody", says Delphine Oudiette, a cognitive neuroscientist at Sorbonne University in Paris, France.

We all undergo the transition from wakefulness to sleep, sometimes several times every 24 hours, and many of us know that it can be an otherworldly journey. That is what inspired Oudiette's interest in it. "I always see stuff when I fall asleep," she says. "Faces, scary faces."

When Oudiette became a sleep researcher, she initially started work on the role of rapid eye movement (REM) sleep in creativity. But she and her colleagues found that the earliest phases of sleep, before REM, also seemed important to creativity. "So we completely changed gear, to sleep onset," she says. She now leads Creadoze, a five-year research project with the French National Institute of Health and Medical Research that is trying to understand this evanescent state and learn how to manipulate it.

Into the shadowland

In sleep research, the SOP has always been a bit of a twilight zone, in part because of the standard methodology used in sleep labs. Polysomnography tracks people's brain activity, eye movements, muscle tone and sometimes other biological signals as they progress through sleep. Researchers divide the output, a polysomnograph, into 30-second "epochs", classifying each as one of five states: wakefulness; the three stages of non-REM sleep, N1, N2, and N3, with each stage leading to progressively deeper sleep; and REM sleep. This standardised system treats the SOP as the start of the first epoch that the scorer classifies as sleep. "The sleep-onset period doesn't exist in the sleep score scoring manual," says Mélanie Strauss, a neurologist at Brussels University Hospital in Belgium.

Slicing sleep into all-or-nothing 30-second chunks is fine for analysing a full night of slumber, but it fails to capture shorter events or transitions between states. For example, an epoch featuring wakefulness and N1 will be scored as one or the other depending on which predominates. But for sleep-onset researchers, this is deeply unsatisfying because, as they are discovering, that transitional state between being awake and sleeping is where the action is.

Researchers – and most people – have long been aware that there is more to the transition into sleep than a simple on-off switch, says Oudiette, in part because of a bizarre, semi-lucid state at the onset of sleep called hypnagogia, featuring hallucinatory, dream-like experiences.

Hypnagogia has been studied since the 1960s, generally by waking people up soon after they drop off and asking them what was going through their minds. This revealed that hypnagogia is both very common and extremely varied, ranging from fleeting sensory experiences – images, sounds, touches, tastes and falling sensations – to vivid dreams almost like those of REM. This content often includes snatches of events from the preceding day and can be influenced by external inputs such as sounds. Perceptions of time and space are often distorted and many subjects report that their hypnagogic experiences are scary. Experiments suggest that around 95 per cent of people experience hypnagogia, but only around half recall it upon waking from a full-night's sleep, says Oudiette.

But hypnagogia is just one part of the SOP. In 1994, trying to understand the phenomenon, Tadao Hori and colleagues at Hiroshima University in Japan recorded electroencephalograms (EEGs) from people as they fell asleep and sliced the traces into 5-second chunks. After analysing them visually and matching them against participants' reports, they proposed that hypnagogia is part of a much longer SOP lasting around 10 minutes. They also identified nine distinct SOP brain states, starting with quiet wakefulness (which they called Hori stage 1) and extending to the beginning of the first phase of N2 (Hori stage 9). "The SOP is a unique period that cannot be accurately categorised as either wake or sleep," they wrote.

Unfortunately, the Hori system turned out

ANTONIO SORTINO

to be difficult to implement. "It's super time-consuming and a little bit ambiguous, you might have a lot of difference between scorers," says Oudiette. "It's kind of a pain." The research didn't go any further.

But in the past few years, researchers have developed new, automated ways of analysing EEGs, some employing artificial intelligence algorithms to recognise subtle patterns occurring on very short temporal and spatial scales. Other imaging techniques, notably MRI, are also being used to probe the SOP in ever finer detail. "We now have the tools to really go deeper in the analysis of this period," says Strauss.

These new techniques reveal the SOP to be complex and turbulent. Some areas of the brain appear to be awake while others are in various stages of sleep, and they can flicker from one to the other at the drop of a hat; for several minutes, the brain is neither fully awake nor fully asleep, but a pulsating mosaic of the two. "It's a succession of different brain states that are different from wakefulness and different from sleep," says Strauss. "It's really dynamic."

Gradually, the fluctuations die down and all regions of the brain settle into a typical N2 pattern of brainwaves. This starts in the thalamus – a sort of neural relay station that passes information between different brain systems – and spreads to the frontal cortex.

Brainwide fluctuations may explain the peculiar perceptual experiences of hypnagogia, says Oudiette, with internally generated dream-like states interacting with external stimuli. It may also explain the enormous variation between individuals' SOP experiences: some people linger for many minutes while others fall off a cliff straight into deep sleep, and this may vary from one night to the next.

The SOP may also be doing important things. The purpose of sleep in general is unclear, although a lot of evidence suggests that it plays a role in memory-processing and generating creativity. And there are hints that the SOP is involved in both.

Memory consolidation – the processing of newly encoded memories into longer-term formats – is an established function of sleep. However, there hasn't been much research on the role of the early stages of sleep in that process, says Oudiette, although what little there is suggests the SOP may be important.

Some of the first research into this area found that people who engage in a new physical or mental task during the day often experience a kind of hallucinatory re-enactment of those tasks as they fall asleep, a phenomenon popularly known as the Tetris effect after people who played the game found they couldn't stop seeing falling bricks as they dozed off.

In 2000, Robert Stickgold, a psychiatrist studying sleep and cognition at Harvard Medical School, used the Tetris effect to investigate the role of hypnagogia in memory, finding that even people who were unable to form new memories still reported seeing *Tetris*-like blocks as they drifted off. The results implied that in sleep onset, people are recalling the day's events and extracting what's meaningful. "It's possible that it is a stage that initiates the memory consolidation that will occur later," says Oudiette.

The fact that hypnagogia sometimes replays experiences from the day is suggestive. So is a recent experiment from Oudiette's group,

"The creativity sweet spot occurs when you start to lose control of your thoughts"

WACHIWIT/ALAMY

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After playing *Tetris* (left), people see blocks as they nod off. The edge of sleep can spark ideas (below)

KAREN HUNT/ALAMY

Thomas Edison used to hold a metal ball in each hand while falling asleep

which found that people who were woken from N1 were worse at recalling the locations of 48 objects on a grid that they had memorised before falling asleep, compared with those who entered N2. Exactly what this demonstrates is unclear. However, Oudiette says it strongly suggests that the SOP may be an important part of memory processing – either by pruning irrelevant information and making room in the synaptic network for memory consolidation, or by tagging, through reactivation, memories that will be reinforced in later sleep stages. In preventing sleepers from descending into N2, researchers may have aborted the tagging process, resulting in those memories being lost rather than reinforced. "I think we still need to have more evidence," says Strauss, who wasn't involved in this research. "But it's very interesting to study."

Hypnagogic memory replay may also be involved in creativity. In the early 2020s, Oudiette was researching the effect of REM sleep on this elusive phenomenon. Volunteers were given a task that required them to try to memorise the position of objects and were told there was a hidden rule that would allow them to solve it instantly. They attempted the task, slept on it, then tried again. "Unfortunately, this experiment failed miserably," says Oudiette. "The rule was too difficult and almost no participants found it." But one participant who did said he discovered it as he was drifting off to sleep. This suggests to Oudiette that the early part of sleep plays a role in creative problem-solving.

In 2018, a team led by Michael Craig at Heriot-Watt University in Edinburgh, UK, had shown that a 10-minute period of quiet rest in a dimly lit room with minimal stimulation significantly boosted people's ability to discover a hidden rule in a different task. But the researchers didn't look at whether the participants had fallen asleep, leaving open the question of whether that state was involved in their success. So Oudiette's group dropped the REM research and reran Craig's experiment with this added step of quiet rest and potential sleep.

They got a group of 103 volunteers to solve the same problem as in Craig's research, called the number reduction task. Participants were asked to transform a given string of eight digits, in this case a series of 1s, 4s and 9s, into a new "solution string" of seven digits using two simple rules, applied digit-by-digit, that were provided by the experimenter. Although it only takes seconds to solve conventionally, there is an even quicker route to solving the puzzle: the last digit of the solution string is always the same as the second digit of the solution string. People who grasp this can finish the task almost instantaneously.

A flash of inspiration

The volunteers completed 60 strings, then – having eliminated 16 who had spotted the hidden rule – the researchers gave them a 20-minute Edison-style rest, reclining in a chair with their eyes closed and a bottle in hand. About half stayed fully awake and a quarter drifted briefly into N1, the first stage of non-REM sleep, before being roused by the falling bottle. The rest fell into N2.

When they returned to the task, 83 per cent of those who entered N1 spotted the hidden rule, compared with 31 per cent of the people who stayed awake and just 14 per cent of the deeper sleepers. The result suggests that a brief foray into N1 can inspire a flash of creativity. "It fits with the definition of creativity, which is producing something that is both original and adapted to the context," says Oudiette. "It's original because we didn't tell them there was a rule and it's adapted because they go faster when they find it."

Other researchers have since made similar findings using different tasks. Last year, Stickgold's lab found that people who had had a short period of N1 were more successful than non-sleepers at three classic creativity tasks. As they fell asleep (or didn't), the subjects were verbally prompted to think about a tree. Then, after being woken, they were asked to write a creative story about a tree, think of alternative uses for a tree and respond to nouns with the first verb that popped into their heads. The sleepers did better in all three tasks. "There's clearly a form of creativity that is massively enhanced by the first few moments of sleep," says Stickgold.

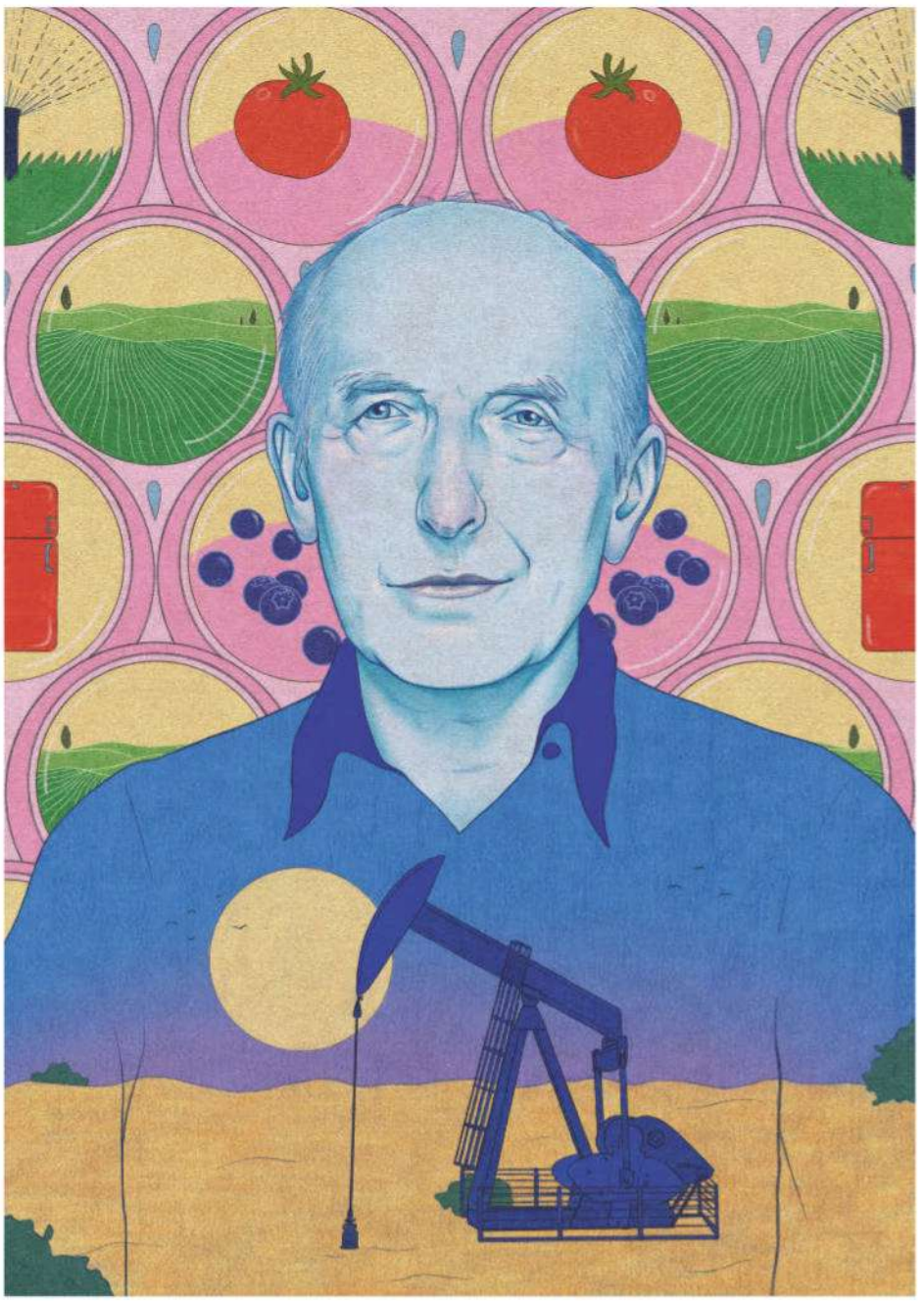
This makes sense: two of the brain networks that are most active during N1 are the default mode network, which generates spontaneous thoughts, and the cognitive control network of higher functions such as attention and planning. According to Oudiette, creativity relies on the interplay between these types of thought, with the former generating random ideas and the latter critically evaluating them.

"I think it's a sweet spot when you start losing the control of your thoughts, you can let it go and have more spontaneous exploration of ideas," she says. "But at the same time, you can still be a bit conscious and evaluate them."

Even if the search for a creative sweet spot in the SOP disintegrates like a half-recalled dream, there are likely to be practical applications. Around a fifth of people have conditions such as narcolepsy or insomnia, where the SOP happens too quickly or takes too long, says Strauss.

A detailed analysis of their individual brain activity could pinpoint where things go awry. It may be possible to employ neurofeedback – using EEG to allow people to watch their brainwaves in real time and learn to control them – to fix the problem. "I can try to teach you how to modify your brain activity to either accelerate or resist sleep, depending on your needs," says Oudiette. Similar techniques could be used to train people to take restorative power naps or foster creativity, she says. "To arrive to that at the end of my project, that is my dream." ▮

Graham Lawton is a staff writer at *New Scientist*



NATALIE FOSS

"We need to understand that food is fundamentally tied to fossil fuels"

Energy and food researcher **Vaclav Smil** tells James Dinneen what is needed to feed 10 billion people this century – without trashing the planet

HERE is a recipe for a thought-provoking, if not wholly appetising, snack: slice up a large tomato and pour over five or six tablespoons of your favourite cooking oil. Depending on where you got your tomato, that oil represents roughly the amount of diesel fuel needed to grow and deliver it to your plate. Bon appétit!

The influential environmental scientist and historian of energy Vaclav Smil came up with this illustration a few years ago – he recommends using dark sesame oil in your salad for the best visual effect. His aim was to highlight the utter dependence of our current food system on fossil fuels, used to run farm machinery, make fertiliser, heat greenhouses, power ships and even generate the electricity that keeps your fridge cool.

As he explains in his new book, *How to Feed the World*, this makes our food system productive enough to feed 8 billion people and rising. It also leaves it rife with inefficiencies and waste, so that food production takes up more than a third of all land not covered in ice, slurps most of the water we use and generates nearly a third of our global greenhouse gas emissions.

Based at the University of Manitoba in Canada, Smil is best known for his work on energy use throughout human history. But several of his more than 30 books have focused on what we eat, including *Feeding the World* in 2001. His latest returns to the topic and lays out some pragmatic steps needed for us to adequately feed our growing population – which is projected to rise to 10 billion people this century – without destroying the planet.

James Dinneen: Why has food been of such enduring interest to you, and what spurred you to write another book on it now?

Vaclav Smil: I'm an old-fashioned scientist, so to me everything is energy, deep down. And the most fundamental form of energy is, of course, food. Besides, I'm a lifelong cook. So I have this close relationship with food. Why I revisited this topic is simple: everything is so polarised these days and that includes the scientific discourse about food. On one hand, you have people telling you, "Oh, we're ›

all going to die by 2030." On the other, you have people saying, "Oh, don't worry, AI will solve everything." I wanted to show that we are not going to die, but that we have problems – and we had better solve some of them.

In the book, you seem frustrated by some common proposals for improving the food system.

Yes, one of the most simplistic examples is the suggestion that we all go totally vegetarian. It's utterly impractical. Most populations will never be vegetarian unless you force them. As soon as people's income goes up, they'll massively increase their consumption of meat. Even India, which is as close to being a non-meat-eating country as it gets, is now eating more. From a very low base, Indian meat consumption has doubled in the past 10 years.

Another proposal is "Let's be totally organic." Well, if you want to have 70 or 80 per cent of people distributing manure on farms, then you can be organic. These are extreme, simplistic solutions – it's not going to work like that.

What aspects of the global food system do you wish were better understood?

One of the most important is that food production is so fundamentally tied to fossil fuels. Without them, the system wouldn't work. These fuels are embedded in things like fertilisers, agriculture, machinery; they are also used directly as fuel for the ships and trucks that move food around. We have kind of a double fossil fuel habit – to produce and to distribute food.

Think of blueberries. Until a few years ago, more or less the only blueberries we had in Canada were from British Columbia. Now, we get blueberries from Peru because they grow them year-round almost on the equator. When we transport blueberries that distance, we are basically moving a little bit of skin and roughage – and the rest of it is 90-plus per cent water. In terms of energy consumption and environmental impact, it's absolutely insane.

Apart from fossil fuels and the associated emissions, what other environmental issues does food production cause?

Nitrogen, which is the crucial ingredient in fertiliser, is one of the biggest problems we have. We have too much of it being applied to farmland in many places, but it's a particularly massive issue in the Netherlands. That country is floating in nitrogen that hasn't been absorbed by crops or animals. In other places, we have too little nitrogen. Think of sub-Saharan Africa,

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Some parts of our food system, like rearing animals for meat (top and left) and producing wine (bottom) have especially negative environmental impacts

where they are using less than 10 per cent of the nitrogen people are applying to crops in Europe, and as a result many of the countries in that area are food insecure.

At least as important as nitrogen, if not more, is water. Again, the problem here is about unequal distribution. Some areas simply don't have enough water, yet despite that, the amount being used is increasing. Look at the characteristic circular farms in the Saudi Arabian desert. They have giant diesel pumps, consuming close to 100 litres of fuel per hour, sucking water from ancient aquifers to irrigate crops, which are then fed to cows to produce milk.

These seem like serious challenges, but you are sceptical of claims that our food system is on the verge of collapse. Why?

In the mid-90s, the environmentalist Lester Brown wrote a famous book called *Who Will Feed China?* He predicted that China wouldn't be able to feed itself. At the time, I wrote a short reply to it, saying, oh, yes, it will. One of the reasons I wrote this book now is that I've been proven right: China is feeding itself. Most people don't realise the Chinese are now producing more food per day per capita than in Japan. More than 3000 kilocalories per day per capita, and they are importing more in order to feed animals. My argument is: if China, with 1.4 billion people, can do it, other countries can too.

How important is waste to this story?

There is what I call "slack in the system", and that slack is tremendous. Let's take the average Western adult living a sedentary lifestyle. If you had 2100 kilocalories per day per capita, that's plenty. But most nations in Europe have about 3500 kilocalories available per person.

Similarly, most Western countries now have a supply of meat available per capita of 70 kilograms per person per year or more. In Spain, it's now about 90 kg of meat per year per capita. You can go down to 50 kg or even 30 kg and be better for it. So, yes, inefficiency and waste in the food system is everywhere.

There is one thing that I call great attention to in my book, and that is simply the wasting of food. You know, globally, 30 to 40 per cent of what we grow will be wasted. What we put our fertiliser, machinery, irrigation and breeding of crops into will be wasted. This is nothing short of criminal. Now, it isn't easy to reduce it massively, but we should be using every means to reduce waste at every point.

> "Globally, 30 to 40 per cent of what we grow will be wasted. This is nothing short of criminal"

What other steps could we take to make food production more sustainable?

The food system is so complicated that you cannot have one or two big solutions; it has to be multifaceted and incremental. Better management of water. Better management of nitrogen. Better management of pasture and croplands. Eating less meat. It's also about eating better-quality food rather than the empty nutrients of processed food. There are thousands of steps that you have to take – and this is true of energy as well. It is true that this is difficult and frustrating. But it's also encouraging because we can attack the problem in so many different ways. Simply eliminating the practice of importing blueberries from Peru isn't going to save us, but it will help a little.

How significant are our personal dietary choices for the sustainability of the global food system?

What individual people eat is inconsequential, it's only when a combination of dietary changes reaches a certain percentage of the population that it makes a difference. Now, some countries have already reached that point. People think about France as a country of wine and meat, both of which are energy-intensive products. But strangely enough, consumption of these in France has actually been declining. A very significant percentage of French people eat meat more or less like we do in my own family – in other words, small amounts and not every day. I did Indian curry last night and cut up little pieces of meat, maybe 100 grams per person. You may even have leftovers.

Could new technologies help make agriculture more sustainable – what do you think about lab-grown meat, for example?

Frankly, I don't think about it. Look, globally, we need hundreds of millions of tonnes of meat every year to meet current levels of demand. Think about how cultured meat is made at the moment, where somebody produces a tiny piece of it on the lab bench and serves it experimentally. Scaling this up isn't going to happen anytime soon.

What might happen sooner, although it's very difficult, is having plants that are like the legumes, in that they coexist with nitrogen-fixing bacteria and so produce nitrogen fertiliser for themselves. That will be a great step. But we've been working on it for decades and we still have a long way to go.

Much closer, in fact we've already succeeded, is to produce, via breeding efforts or genetic modification, more drought tolerance or more salt tolerance in the varieties of crops we already grow, from rice to wheat to potato. If you have a little more salt tolerance, you can irrigate with brackish water. So that's the way to go, to breed the crops with higher tolerance to extreme environmental conditions.

You suggest in your book that we are effectively eating fossil fuels. Do you foresee a day when we could instead talk of eating wind and solar energy?

It is a tricky question because there is no shortage of fossil fuels. We will never exhaust them, we will simply stop extracting them when it becomes environmentally unacceptable or they get too expensive. But yes, eventually we'll get to the point when fossil fuels will be the minority of our supply and eventually they will be negligible. But certainly not before 2050, that's for sure. ▮

James Dinneen is a reporter for *New Scientist* based in New York

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Matters of time and malevolent book displays p56

Twisteddoodles for *New Scientist*
Picturing the lighter side of life p56

Debunking gardening myths

Bad pot luck

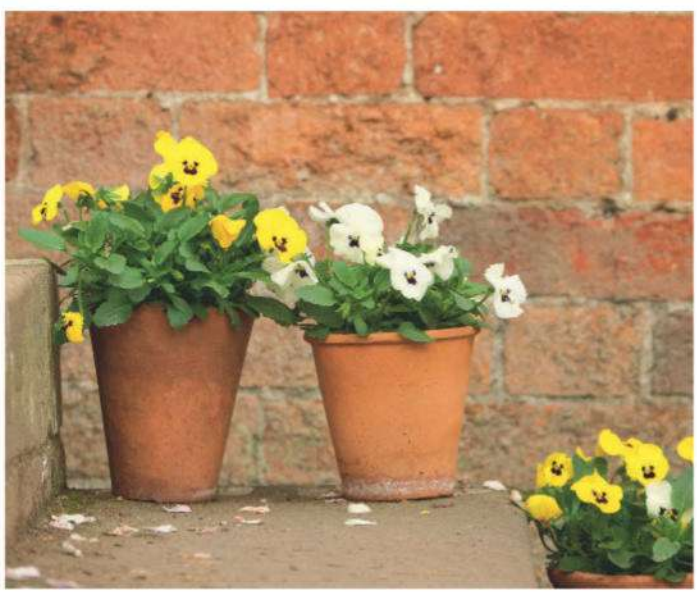
For nervous newbie gardeners, starting out with a potted plant might seem the easy option. **James Wong** explains why it isn't

James Wong is a botanist and science writer, with a particular interest in food crops, conservation and the environment. Trained at the Royal Botanic Gardens, Kew, in London, he shares his tiny flat with more than 500 houseplants. You can follow him on X and Instagram @botanygeek

AS SOMEONE who has been weirdly obsessed with growing things since I was a kid, I am always perplexed about how fearful beginners can be when it comes to gardening. This is probably why, when I ask nervous newbies about their first attempts, they invariably say they wanted to start with something manageable: a single plant in a small pot. The horticultural industry has ingrained this idea with glossy campaigns for beginners to start with pots. But here's the kicker: growing in pots is actually far more likely to result in failure – and it is all down to simple physics.

It might seem like a trivial difference to human onlookers, but from the plant's perspective, having its roots in a pot versus open ground can have a profound impact on two key determinants of its growth: water and temperature. The lower ratio of volume to surface area means plants in pots dry out faster than they will in the ground, as the smaller volume of potting mix is less able to hold onto moisture. This is particularly the case in containers made from porous materials, like unglazed terracotta.

Similarly, a pot's smaller volume means it heats up much faster in summer and is quicker to freeze in winter, creating fluctuations in temperature that plants like these pansies, pictured, may struggle to adapt to. This is why on really hot days, hanging baskets and window boxes can need watering up to twice a day, while the same plants in the ground may need it just once a week.



SIMON ANNABLE/ALAMY

Even if you set up an automated irrigation system (and what beginner is going to do that?) there is another key reason why plant growth can suffer in pots. Horticulturists have known for centuries that restricting the growth of roots using small pots has a mirror effect on the plant's size above ground. This has been the basis of bonsai culture since classical times.

Trials have shown that the effect can have sizeable and long-term impacts on plant health. Plants rely on their roots to take up the water and nutrients to fuel their growth, so restricting space has an overall impact on their vigour.

Finally, let's talk nutrients. In healthy garden soil, microbes unlock minerals and other compounds beneficial for plant growth. In pots, the medium used tends to not be soil but substances like peat, which both contains far lower levels of nutrients and lacks the ability to support the microbial life that makes these nutrients available.

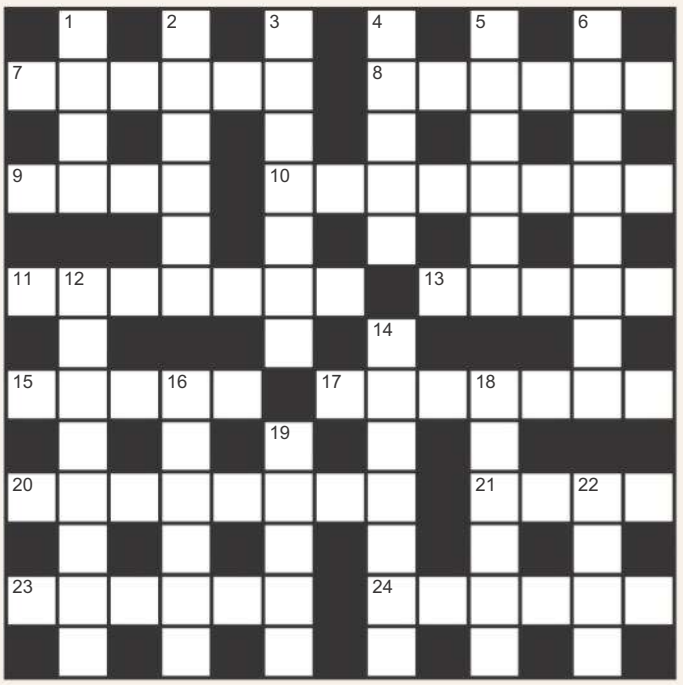
Moral of the story? For pretty much every aspect of health, growing in the ground will require fewer inputs from you and a more stable environment for the plant. So if you have failed at your first horticultural foray in a pot, don't blame yourself! You were set up for failure. Try growing the same plant in open ground and thank me later. ▮

Debunking gardening myths appears monthly

Next week
The science of exercise

These articles are posted each week at newscientist.com/maker

Cryptic crossword #147 *Set by Trurl*



Scribble zone

Answers and the next quick crossword next week

ACROSS

7 Welshman in space station, where pilot might be (3-3)
8 Structure for entrapment of male relation casually going back on the internet (3,3)
9 To date one, you'd have to search the Himalayas to find one (4)
10 Very little innovation in reinterpretation of the canon (8)
11 Perry, perhaps, accomplished in cricket (7)
13 Go off to cool one's feet after losing head (5)
15 Shilling in America, having hole in head (5)
17 Perhaps escape towards Sunset Island (3,4)
20 Write and ask, rudely, to be towed, speedily (5,3)
21 *Star Wars* ship, having jettisoned weight, finds short way to traverse route (4)
23 An old lover, we're told, may be an addition to one's home (6)
24 Suspended beside train tracks for wanting more (6)

DOWN

1 Can "east" be a point? (4)
2 Labour perhaps overwhelming one in state where everyone is equal (6)
3 Astronomical event where time went rapidly – it's chaotic (7)
4 Tied around site of injury (5)
5 Subsided in bidet – a bad reversal! (6)
6 The woman copper with the French labourer? (8)
12 A villein in France initially given a measure of space (not applicable for birds) (8)
14 Get going again with arithmetic, say, 8 divided by 50? (7)
16 Reuter's repaired water pipe (6)
18 Getting bigger and balder (6)
19 Wood, perhaps, remains (5)
22 Average guy? (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #275
set by Bethan Ackerley

1 Aperiodic monotiles can sometimes be referred to by what name? (One they share with a prominent 20th-century physicist.)

2 What does the GPT in ChatGPT stand for?

3 Philosopher John Searle created which thought experiment regarding artificial intelligence?

4 Medicines that alter contractions of the muscles are described as what?

5 Astronaut Gus Grissom was killed in which mission?

Answers on page 55

BrainTwister
set by Katie Steckles
#43 Consecutive sums

Consecutive numbers are ones that follow on from each other in order, like 2, 3, 4 and 5. We can create certain numbers by adding together runs of consecutive numbers, e.g. 1 + 2 + 3 = 6 or 14 + 15 = 29.

Can you write 14 as a sum of two or more consecutive positive numbers?

Which numbers below 20 cannot be written in this way, and is there a pattern?

Solution next week

Discovery Tours

NewScientist

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Red or blue pill?

Is there any scientific evidence disproving the notion we are part of a vast simulation run by an advanced civilisation?

Nick Canning
Coleraine, County Londonderry, UK
What sort of simulation are you considering? The *Matrix* films envisioned a large, multiplayer "game" in which protagonists existed both within the game, in the form of simulated information, and outside the simulation, as flesh and blood.

But how do you know that this second level isn't part of a larger simulation? An infinite regression is thus possible, invoking ever larger simulations and requiring ever larger computing resources (memory, processing power and energy consumption).

However, considerations of the information content – for the resolution and extent of the simulation required for the whole universe potentially experienced by over 8 billion independent consciousnesses and their interactions, let alone all the other species and objects in the world – gives us pause. This would be comparable to the information content within a black hole.

"If a simulator attains the size required to run the simulation of 8 billion minds, it would collapse behind an event horizon"

If a simulator attains the size, mass and energy consumption required to run the simulation, it would collapse under its own gravity behind an event horizon. This makes the hypothesis highly unlikely!

Mike Follows
Sutton Coldfield, West Midlands, UK
The simulation hypothesis was first mooted by Nick Bostrom, a philosopher at the University of Oxford. It argues that we are all likely to be living in a scaled-up version of something like *The Truman Show*, a film released in 1998 starring Jim Carrey as Truman Burbank.

However, whereas Truman was living on a physical film set watched by millions of TV viewers, we would all be acting out our lives as 0s and 1s inside a highly sophisticated computer model, our interactions and perceptions of the world around us dictated by algorithms written into the software by an advanced civilisation.

Whether we will ever be able to test this hypothesis might depend on future advances in science and technology. In the meantime, it would depend on us spotting detectable "glitches" as Truman Burbank did.

Bernd-Juergen Fischer
Berlin, Germany
I'm afraid there cannot be any scientific evidence that proves that we aren't part of a simulation, because if you presented me with such a "proof", I would simply say: "Now look how clever the simulation is!"

And, of course, a perfect simulation of some "reality" by the inmates of that reality would be required to have us believe that we live in the reality, because otherwise the simulation wouldn't be perfect.

A reader of *New Scientist* complained recently that she might as well stop sorting her bottles and cans if she lived in a simulation (Letters, 7 September). Don't! Even if you aren't saving the real world, you are saving the simulation, and either way that is all you have got.

Do Kester
Zuidhorn, The Netherlands
Science is driven by the notion that it should explain nature in as simple terms as possible. This principle, known as Occam's razor, is named after the medieval monk William of Ockham. As he stated it: "entities should not be multiplied unnecessarily".

Let us look at the entities in two theories: the universe is as it seems, containing about 10^{80} particles, or the universe is a simulation of 10^{80} particles inside a computer run by an advanced civilisation. Assuming this civilisation is physical, it lives in a universe of similar dimensions. These universes not only contain particles, but also structure – galaxies, stars, planets, life, brains, civilisations, technologies – making the theories even more complicated.

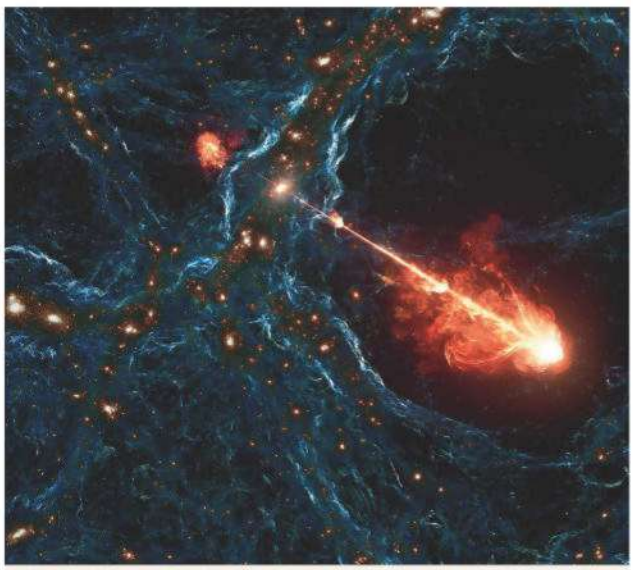
It is obvious that the second theory needs vastly more entities than the first: an extra universe of entities, while they don't explain anything new.

So as long as no "Easter eggs" pop up among the stars saying "Ha ha, you are a simulation", the scientific choice would be with Occam.

Herman D'Hondt
Sydney, Australia
While many people consider a vast simulation possible, or even likely, I am struck by the significance of the fact that, if it were true, we are being simulated by "someone".

The scientist in me would then ask the question: what makes you think that our simulator is real? There is no reason to expect that our simulator is the be-all and end-all. Who simulates the simulator? Where does it stop?

Or, with apologies to Carl Sagan, is it simulators all the way down?



E. WERNQUIST/D. NELSON/ILLUSTRISTNG COLLABORATION/M. OEI

If a jet from a black hole struck Earth or the sun, what would happen next?

This week's new questions

Jet stream **What would happen if a black hole jet hit the sun or Earth?** ***Doug Kalning****, Cary, North Carolina, US*

Getting hairy **Why do we start growing copious amounts of ear, nose and eyebrow hair as we get older? How can this possibly help us survive in our twilight years?** ***David Bloomquist****, Venice, Florida, US*

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Tom Gauld
for New Scientist

Equally speedy

How do we know that gravity has the same speed as light? And why is this the case?

Ron Dippold
San Diego, California, US

In Newtonian physics, gravity was thought to be instantaneous. But in Albert Einstein's general theory of relativity, the speed of light, *c*, is the fastest possible speed for any interaction that carries information, not just light. Gravitational waves carry a lot of information, which we measure with detectors like LIGO and Virgo.

Unfortunately, gravity is by far the weakest force, so the speed of gravity hasn't yet been precisely measured in a laboratory. Instead, we have to turn to nature's laboratory. In 1859, astronomer Urbain Le Verrier showed that Mercury's orbit precesses (changes) in a way that couldn't be fully explained by Newtonian gravity. This orbital puzzle was only solved after Einstein published his general theory of relativity in 1915.

"Gravitational wave detector LIGO spotted two neutron stars colliding 2 seconds before telescopes saw the gamma rays"

For a more precise measurement of the speed of gravity, we can turn to binary pulsars. A pulsar is a rotating neutron star that shoots a beam of electromagnetic radiation from each of its poles. Every time a pulsar's rotation sweeps a beam across Earth, we see a spike of radiation. The rotation of pulsars is extremely regular, making them excellent clocks.

When one of these is rotating around another neutron star or white dwarf, their gravity fields drag on each other, slowing them both down. The Hulse-Taylor binary pulsar was the first discovered and has been studied extensively. The rate of slowing is directly related to the speed of gravity, and for this system (and other binary pulsars) it is within 1 per cent of the speed of light.

Since LIGO came online, we can also compare when telescopes see major astronomical events with when we "see" them with LIGO. In 2017, LIGO detected two neutron stars colliding 2 seconds before telescopes saw the gamma rays, in the GW170817 event. This happened 130 million light years away, so if gravity waves travelled at anything other than the speed of light, there would have been a huge time difference.

Again, the "why" is because, in general relativity, the "speed of light" is really the conversion factor between the three dimensions of space and the dimension of time in space-time. Nothing real can travel faster than it. Of course, in quantum theory, entangled particles appear to violate this, which is one reason why a theory of quantum gravity has been elusive so far.

But at this point, we are very sure the speed of gravity is near the speed of light and is likely to be the same. ▮

Answers

Quick quiz #275 *Answers*

1 Einsteins, though this isn't through any connection to the work of Albert Einstein, rather it is a play on the German words for "one stone"
2 Generative pre-trained transformer
3 The Chinese Room
4 Inotropic
5 Apollo 1

Quick crossword #169 *Answers*

ACROSS 1 Fathom, **4** Go deaf, **8** Printer, **9** Aileron, **11** Widescreen, **12** Dick, **13** Azoic, **14** *Outbreak*, **16** New media, **18** Night, **20** Kiln, **21** Lassa fever, **23** Biotech, **24** Alcohol, **25** Maersk, **26** Tsetse

DOWN 1 Fermi, **2** Tangelo, **3** Oleic acid, **5** Orion, **6** E-reader, **7** Flowchart, **10** Menopause, **13** Americium, **15** Tentacles, **17** Manatee, **19** Greyout, **21** Locus, **22** Erode

#42 Persistence *Solution*

The persistence of 77 is 4 and its root is 8: 77→49→36→18→8.

The smallest number with persistence 1 is 10.

No two-digit number has a persistence greater than 4 (and 77 is the only two-digit number with a persistence of exactly 4).

The 17th Feedback

Feedback is feeling peculiar. The mood swings are even more drastic than usual, to the point of constituting a whole new personality. It is as if, like a Time Lord, Feedback has taken an insufficiently homeopathic dose of strychnine and been forced to regenerate into a whole new body with a radically different mind.

One immediate mood alteration is that Feedback is now suffering from severe FOMO. Specifically, we have the FOMO that comes of living slightly too far south to see the recent aurora borealis displays. Happily, those selfless people at Meta (owners of Facebook, Instagram and all your personal data) provided some AI-generated images of auroras for those of us that didn't see them. A fake image is definitely a good substitute for seeing a beautiful natural phenomenon, so thank you Meta.

Anyway, please bear with us as we go through this unsettling transition. Feedback is not entirely sure what it is going to look like from now on, so we asked for suggestions from our nearest and dearest. Mrs Feedback suggested the all-too-practicable approach of ripping off a load of jokes from social media sites that most readers won't look at. Meanwhile, Feedback Jr gave a blank stare, asked why on Earth anyone would call a column "Feedback" when it isn't the letters page and then demanded food. ("It's because it is on the back page. You see, there are these things called print magazines...") Feedback's Felines were similarly unhelpful and even more insistent upon nutrition.

High midnight

Feedback is pleased to report a happy accident. By making what can only be described as a rock-stupid mistake, Feedback has inadvertently discovered a way to massively reduce inefficiency in the global economy. All it will take is an enormous amount of developer time.

Twisteddoodles *for New Scientist*

ZOMBIES ARE EVERYWHERE! HOW COULD THIS HAPPEN?
EARLIER...
IT'S DECIDED, WE'LL ENTRUST THIS VIRUS TO OUR CLUMSIEST SCIENTIST
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Got a story for Feedback?
Send it to feedback@newscientist.com
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Consideration of items sent in the post will be delayed

Needing to book an online appointment, we used one of those websites where you pick a slot on a calendar. Feedback went for noon. But when we sat down at the computer a few minutes beforehand, the website said we were a "no show". This seemed presumptuous, as we were early. But then Feedback realised the slot was labelled "12:00 am", which is midnight, not noon. Feedback is a twit.

After rebooking, Feedback apologised to the person on the other end – who admitted they recently did the exact same thing. This got Feedback thinking. How much time is wasted by booking websites that make it too easy to timetable something for midnight when you mean noon? The costs to the economy in lost productivity and laptops hurled at walls must be staggering. Surely it wouldn't be too difficult to have a pop-up any time somebody books at midnight, saying "Are you sure you didn't mean noon?" User experience designers, your time has come.

Booksellers gone rogue

Writer Sunyi Dean was passing through London's Heathrow Airport when she spotted a copy of *Unleashed*, the autobiography of Boris Johnson, one of the UK's many recent former prime ministers. The unusual manner in which the book was displayed prompted Dean to take a photo and share it on BlueSky, which if you haven't used it is like X but with fewer white supremacists. This is one of those cases where a picture is worth a thousand words, but Feedback has a word count to fill, so: Johnson's tome was sandwiched between two books by Thomas Erikson, called *Surrounded by Liars* and *Surrounded by Idiots*.

Two matters arise from this. First, Feedback wonders about other eccentric or malevolent ways to display science or science-adjacent books. A few obvious possibilities present themselves, like moving Graham Hancock's books into the science fiction section. Booksellers might also consider inventing some new genres within which to display themed sets of popular titles. Feedback has identified a few emergent trends, including "perennial claims that string theory will fix physics", "radical solutions to the consciousness problem that unsurprisingly turn out to involve quantum mechanics" and "writers too famous to allow themselves to be edited for length". Readers who have noticed similar clusters of titles are invited to submit them to feedback@newscientist.com.

Feedback was also curious about Erikson's *Surrounded by...* books, displayed in our local bookshops in the self-help and business sections. It turns out *Surrounded by Idiots* promotes a hypothesis that personalities can be divided into four types, labelled with colours. This was developed by psychologist William Moulton Marston, better known as the creator of Wonder Woman, and formalised into a system called DISC (dominance, influence, stability and compliance, or possibly dominance, influence, steadiness and conscientiousness, depending where you look).

Our spidey sense tingled upon reading this. Most commercial personality tests are notoriously unreliable. Might this be a load of cobblers? Feedback found a detailed Medium post by a psychologist, which said: "the four-colour model is based on a theory that has no scientific basis, has been subject to no rigorous testing and gives confusing and contradictory results." Yup, likely shoe repair practitioners.

In sum, Johnson's book is surrounded by books about being surrounded by idiots that are themselves idiotic. It's almost too perfect.

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